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RICHARD TREVITHICK.

WRITING to his friend Davies Gilbert, Trevithick in his last illness, 1853, said, "I have been branded with folly and madness for attempting what the world calls impossibilities, and even from the great engineer, the late Mr. JAMES WATT, who said to an eminent scientific character still living, (Mr. John Isaac Hawkins), that I deserved hanging for bringing into use the high pressure engine. This so far has been my reward from the public; but should this be all, I shall be satisfied by the great secret pleasure and laudable pride that I feel in my own breast from having been the instrument of bringing forward and maturing new principles and arrangements of boundless value to my country. However much I may be straitened in pecuniary circumstances, the great honour of being a useful subject can never be taken from me, which to me far exceeds riches."

These words are the key-note of any biographical notice of Richard Trevithick, and they establish his claim to the esteem of succeeding generations. His son Francis, who has recently been taken from us wrote as perfect a memoir as the scanty materials could afford, and it is from that work—abating a little the natural and filial partiality,—that this general notice of him is written. The other notices are included, such as Woodcroft, Edwards, Pole, and Smiles, the last of whom writes in terms of detraction arising from a habit of worshipping success The Stephensons can afford to live for ever on the works they have done, and need no idolatry to sustain their reputation, nor would they desire that the rivalries of life should be continued by any ungenerous remarks addressed to succeeding generations with a quasi-authority.

Trevithick held the managership of important Cornish lead-mines when thirty years of age; he resided near that at Dolcoath, the oldest, richest, and most famous of such works in that county. In many parts lead lay near the surface, and a qualified man had no difficulty in undertaking a general superintendence of several works, going from place to place, but residing at the largest.

Trevithick manifested his great engineering genius at Dolcoath, when he constructed the "deep adoit" there; that work still drains many mines and reduces the level for outflow by 60 or 70 feet of many others, although it was made a century ago. He had, in common with many, heard of the newly discovered steam power, and perceived therein the existence of future opportunities that would benefit all who should make its development a study and a profession. He determined to be one of those.

There is a perpetual attractiveness in the humble aspect of the homes of those who, in after years, have been benefactors to their kind. We look at the old wood-cut representing

Shakespeare's house, and that of Bunyan at Elsted, and of many others, and feel that poor and rugged as they are, and in their appointments most unlike the grand result of the lives there cherished, they witness to the worth and power of the rough peace belonging to a lowly condition when hallowed by contentment and labour. Such was the elder Trevithick's home at Dolcoath mine in 1760, where he evolved his early enterprises. At that date the mine had two atmospheric steam-pumping engines, that raised water for working the pumps, the mineral being brought up by horse power, as indeed was the water from the shallow levels, for steam had not then been made use of in mining operations. Trevithick initiated the principle of forcing out the foul by forcing in the pure air—a principle which is the only sound one in all ventilating efforts. This he did by means of the steam engine in 1765; before Watt's first engine in Cornwall he re-erected the Carloose engine in the Dolcoath

Fig. 1.—Residence of Trevithick as it appeared in 1871.

mine. Here for the first time we get an account setting forth the monies paid for engines, labour, boilers, and cylinders. The engine was one of Newcomen's early construction, and had been there more than sixty years. Trevithick made of it a new one, and Cornwall was very proud with his success in improving the gear and valves, and introducing a self-acting principle. He took away the old flat top that had to be weighted with granite, and substituted a semi-circular one, thereby developing

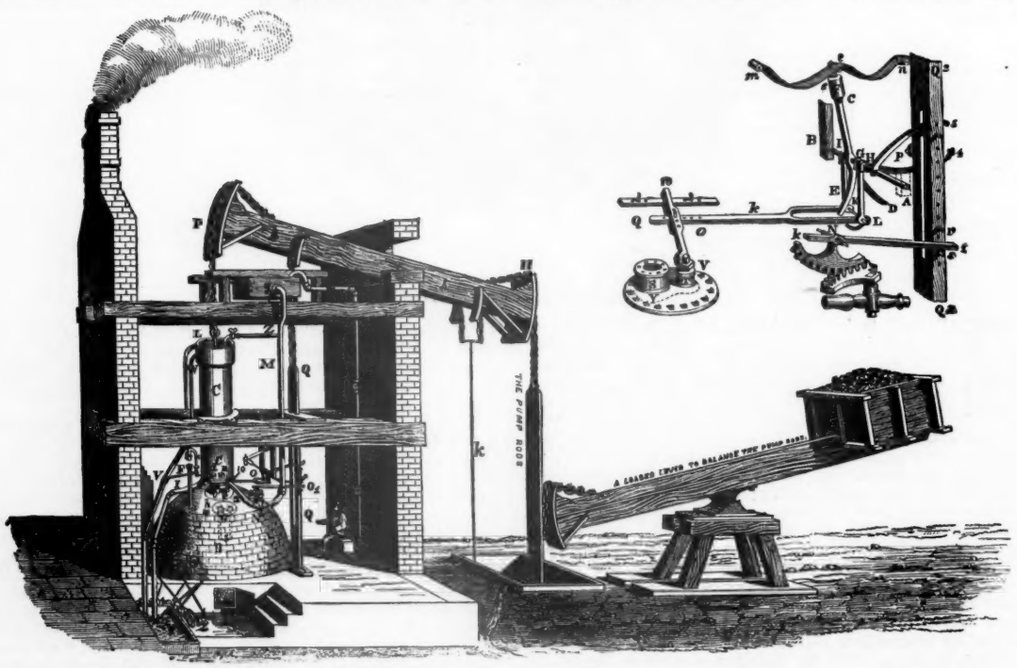


Fig. 2.—Newcomen Atmospheric Engine, improved and re-erected by R. T. Sen., at Bullen Garden, 1775.

Newcomen's idea when he made cylindrical sides in order to give strength to the parts. Having made this improvement, and noting the immense advantage, his thoughts turned to the subject of a higher steam pressure. His engine could stand it, and why should he not try?

This reconstruction, which is described in detail by Mr. Pryce

in his Mineralogia Cornubiensis, 1778, and illustrated by a large engraving, from which the sketch (Fig. 2) is copied; it cost £2040, which is about equivalent to our £6500—a large sum in unscientific days—but a proof that Trevithick had the confidence of those about him.

This new contrivance for draining mines had a curious but significant designation—"raising water by fire"—where the steam to raise the water from the greatest depth of mines is not required to be greater than the atmosphere. After setting forth the meaning of the terms horse-power and man-power as applied to the capabilities of steam engines, Pryce describes this particular engine, and it is a description which must be of value to young engineers. (P. 153 *et supra.*)

"B is a large boiler, whose water, by the fire under it, is converted into an elastic steam. The great cylinder CC is fixed upon it, and communicates with it by the pipe Dd, on the lower orifice of which, within the boiler, moves a broad plate, by means of the steam cock, or regulator, E10, stopping or opening the passage to prevent or permit the steam to pass into the cylinder, as occasion requires. The diameter of the pipe D is about four inches.

"The steam in the boiler ought always to be a little stronger than the air, that, when let into the cylinder, it may be a little more than a balance to the external air which keeps down the piston at the bottom *d*, *n*. The piston being by this means at liberty, the pump rod will, by its great weight, descend at the opposite end to make a stroke, which is more than double the weight of the piston, &c., at the other end. The end of the lever at the pump, therefore, will always preponderate and descend when the piston is at liberty. The handle of the steam cock E10, being turned towards *n*, opens a pipe, D, to let in the steam, and being turned towards O, it shuts it out, that no more can enter. The piston is now raised towards the top of the cylinder at C, and the cylinder is full of steam. The lever O1 must then be lifted up, to turn, by its teeth, the injecting cock at N, which permits the water, brought from the cistern *g*, by the pipe *g* MN to enter the bottom of the cylinder at *n*, where it flies up in the form of a fountain, and striking against the bottom of the piston, the drops being driven all over the cylinder, will, by their coldness, condense the steam into water again, and precipitate it to the bottom of the cylinder."

Mr. Pryce describes Beighton's experiments on the rarity of steam mathematically, and then proceeds with this engine—"Now this whole operation of opening and shutting the steam regulator and injection cock, will take up but little more than three seconds; and will, therefore, easily produce 16 strokes in a minute." He then notes the arrangement for supplying the cistern *g* with water as seen in H *k* and *m m m*, and also the means for keeping the leathers of the piston C in working condition by the means of water *M* Z L W, and resumes—

"The water in the boiler, which wastes away in steam, is supplied by a pipe I *i* about three feet long, going into the boiler a foot below the surface of the water. On the top of this pipe is a funnel I, supplied by the pipe W with water from the cup of the cylinder, which has the advantage of being always warm, and, therefore, not apt to check the boiling of the water. That the boiler may not have the surface of the water too low, which would endanger bursting, or too high, which would not leave room enough for steam, there are two gage pipes at G, one going a little below the surface of the water when at a proper height, and the other standing a little above it. When everything is right, the top cock of the short pipe being open, gives only steam, and that of the one long water; but, if otherwise, both cocks will give steam when the surface of the water is too low, and both give water when it is too high; and hence the cock which feeds the boiler at I may be opened to such a degree as always to keep the surface of the water to its one height.

"Lest the steam should grow too strong for the boiler, and burst it, there is a valve fixed at *h*, with a perpendicular wire standing up from the middle of it, to put weights of lead upon in order to examine the strength of the steam pushing against it from within. . . . . The steam has always a variable strength, yet never one-tenth stronger or weaker than common air, for it has been found that the engine will work well when there is the weight of 1 lb. on each square inch of the valve. This shows that the steam is 1-15th part stronger than the common air. Now, as the height of the feeding pipe, from the funnel F to the surface of the water G *s* is not above three feet, and three feet and a-half of water is 1-10th of the pressure of the air, if the steam were 1-10th part stronger than air, it would push the water out at E." He then dilates on this subject to confirm his proposition, and goes on—

"Among the great improvements of this engine, we may reckon that contrivance by which the engine itself is made to open and shut the regulator and injection cock, and that more nicely than any person attending could possibly do it. For this purpose there is fixed to an arch 12 at a proper distance from the arch P, a chain, from which hangs a perpendicular piece or working beam QQ, which comes down quite to the floor, and goes through it in a hole, which it exactly fits. This piece has a long slit in it, and several pin-holes and pins, for the movement of small levers destined to the same office of opening and shutting the cocks after the following manner:—Between two perpendicular pieces of wood, on each side, there is a square iron axis, AB, which has upon it several iron pieces of the lever kind. The first is the piece CED, called the Y, from its representing that latter, inverted by its two shanks E and D; on the upper part is a weight, F, to be raised higher or lower, and fixed as occasion requires. This Y is fixed very fast upon the said iron axis AB.

"From the axis hangs a sort of iron stirrup, IKLG, by its two hooks, IG having, on the lower part, two holes, KL, through which passes a long iron pin LK, and keyed in the same. When this pin is put in, it is also passed through the two holes in the ends EN, of the horizontal fork or Spanner EQN joined at its end Q to the handle of the regulator V10. From Q to O are several holes, by which the said handle may be fixed to that part of the end which is most convenient. Upon this axis AB is fixed at right angles to the Y, a handle or lever G4, which goes on the outside of the piece Q2, Q2, and lies between the pins. Another handle is also fastened upon the same axis, viz., H5, and placed at half a right angle to the former, G4; this passes through the slit of the piece Q2, Q2 lying on one of the pins. Hence we see that when the working beam goes up, its pin in the slit lifts up the spanner H5, which turns about the axis so fast as to throw the Y, with its weight F, from C to 6, in which direction it would continue to move after it had passed the perpendicular, were it not prevented by a strap of leather fixed to it at Q2, and made fast at the ends *m* and *m* in such a manner as to allow the Y to vibrate backwards and forwards about a quarter of a circle at equal distances, on this side and that, of the perpendicular."

In the year following Trevithick's engine, Watt erected his first working engine and went to Cornwall in 1778 to inspect their condition and working. After some business had been transacted, Watt writes to Boulton, "In came Captain Trevithick who fell foul of our account, labouring to demonstrate that Dolcoath engines not only surpassed the table, and concluded by saying that we had taken or got the advantage of the adventurers. . . . During all this time I was so confounded with the impudence, ignorance, and overbearing manner of the man that I could scarcely keep my temper and could make no defence." We have nothing now to do with this condition of jealousy, save to report the fact, as put by Mr. Smiles, who, as we venture to think, is rather hard on the provincial man at the extreme part of the island. Watt declared war against Trevithick by pitting his low-pressure steam low engine against the improved high-pressure steam engine of the latter, and no wonder the man turned round and surprised the great engineer with the boldness of his conception. There was a custom among "Captains" as they were called, whereby they, as managers, were allowed a proportion of the balance saved in coal, and Trevithick, Watt, Bull, and young Trevithick all effected considerable sums for themselves, proving that all their engines were good enough.

Trevithick had the highest jealousy about the steam engine, and hated the monopolising spirit of the great inventors, when they, after coming late, sought to depreciate his abilities. He made all his own in the mines, and had no royalty beyond the coal savings; he had the precedence of his great rivals in these particular machines. Twenty years of law ensued, and all were pretty well worn out. The value of their engines had been going down by a course of improvements in constructing new ones, and by-and-bye Trevithick, having worked fifty years, handed over the dominion to his son, who took up the work and drawings, plans, models, ideas of his father with great vigour and success. He was working for 3s. 6d. a-day, and as fierce a rival of Boulton and Watt as he continued bringing out improvements that kept clear of their patents.

Here is an instance: James Bolitho "had worked in Ding Dong for fifty years; his father, Thomas Bolitho, worked all his life in the mine, and frequently spoke about the engine that Captain Trevithick had put up. She had not worked long before Boulton and Watt came down with an injunction printed out, and pasted it up on the door of the engine-house, and upon the heap of mine-stuff, and nobody dared to touch them. But Captain Trevithick did not care, he and Bull and William West came and turned the cylinder upside down, right over the pump-rods in the shaft; they took off the cylinder top, (it was the cylinder bottom before they turned it upside down); water and oil used to be on the top of the piston to keep it tight.

Captain Trevithick at that time put a wind engine in the mine. Sometimes it went so fast that they could not stop it."

This was one of the many skirmishes with Watt, causing the engine to work as an open-top cylinder atmospheric rather than pay patent demands.

Trevithick, junior,—we will call him Trevithick after this,—had the good luck to acquire the friendship of Davies Gilbert, the learned historian of Cornwall, and he writes, "On one occasion Trevithick came to me and inquired with great eagerness as to what I apprehended would be loss of power in working an engine by the force of steam raised to several atmospheres, but instead of condensing to let the steam escape. I of course answered at once that the loss of power would be one atmosphere diminished power by the saving of an air-pump with its friction, and in many cases with the raising of condensed water. I never saw a man more delighted, and I believe that within a month several puffers[1] were in actual work."

This high-pressure engine may be said to date from 1796. Trevithick was commonly known as the tall strong young man who cared not for Watt and gave evidence against him in 1796. The idea of working an engine by the pressure of steam flashed on his mind as a real and important discovery; his scientific friend Murdoch, who was perfectly conversant with Watt's engine saw it in the same light, but did not see its practical bearing. "A puffer-engine would lose the power from vacuum, minus the power required to work the air-pump, and the conveyance of condensing water." This is the description of the difference between the low-pressure engine of Watt commonly called Steam Engine, and Trevithick's, which relied on the pressure of steam for its power. Trevithick saw it, and within a month a dozen were at work. This is the locomotive engine, wherein the vaccum engine of Watt could not be used.

The increasing depths of mines and augmenting power of engines brought about a change in the rude pumps made of wood, iron-hooped, having buckets with leather-cups, packing and valve, which could only raise by the upward motion of the rods. Pistons without valves, as used in steam engines worked in brass or iron pump-barrels, forced the upward with their downward motion and reduced the strain one half, because their descending weight balanced the weight of ascending water. Trevithick made his Plunger-pole pump in 1797. Its great value is its simplicity. It is used now as it was then. Such pumps were much needed.

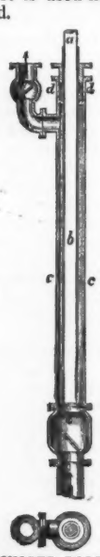


Fig. 3.—PLUNGER-POLE PUMP, 1797.

a, the pump rod, of wood, fastened into the hollow cast-iron pole; *b*, the pole or plunger; *c*, the pole-case, allowing space for the passage of water round the pole; *d*, the stuffing box; *e*, the bottom valve, allowing the mine water to ascend into the pole-case on the ascent of the pole; *f*, the top valve through which the water is forced upward on the descent of the pole.

This led to the introduction of water pressure engines in 1799. Trevithick soon worked one in a mine, and as he had several mines under management they soon became well known.

"The fall of water is 13 fathoms; the engine works double; 9-feet stroke. The parts are, a tube communicating with the head of water; the cylinder; a tube communicating therewith; a tube acting as a syphon, and thus adding the length of the cylinder to the head of water. When the cock is turned, the water from the tube presses on the piston in the cylinder. The water under the piston is forced up the tube and flows down the syphon." In this illustration the balance valves are replaced by the fourway cock. It looks to be a bundle of tubes, but its great power and economy in working led to its use in various parts of the kingdom.

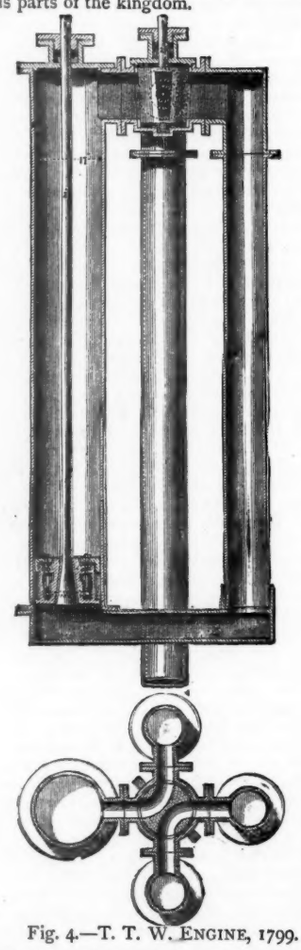


Fig. 4.—T. T. W. ENGINE, 1799.

The history of the common locomotive is another illustration of what results from small beginnings if we only start on right principles. Trevithick made a model described as follows: "A boiler something like a strong iron kettle was placed on the fire. Gilbert was stoker, and blew the bellows, Lady Dedunstantonville was engine-man, and turned the cock for the admission of steam to the first high-pressure engine. The model was brass. They made another to run round the table or room, in which the boiler and engine *were in one piece;* hot water was poured into the boiler, and a red-hot iron put into an inner tube as in a tea-urn. They made another heated by a spirit-lamp, and that one was taken to town by a gentleman who came down to observe the work.

Trevithick had two years' labour in working experiments and under the pressure of poverty. Trade happened to be bad, and the contentions at law did not bring revenue or confidence among his "fellow-captains." He was sure that a steam engine could work without air-pump or condensing water, and that there was no necessity for beam, parallel motion or masonry for foundations; he also saw that a quarter of the weight or cost of the low-pressure boilers then in use would give equivalent power.

His account book of 1800 details the prime cost. West worked for two or three years on model-making; others improved the mining engines at work under him with a view to

[1] *Puffers.*—A name given to steam engines in old times on account of the sound they emitted when working.

see the way for a better form, and in the meantime he utilized his men in setting up a steam-carriage at Cambourne of which the items of cost remain to this day. In 1801 he was in London about the patent, and also looking after the engineers, and on Christmas eve, 1801, he conveyed the first load of passengers ever moved by steam. They started from Tyack, the blacksmith's shop. Captain Dick got up steam in the high road. An old workman writes, "When we see'd that Captain Dick was going to turn on steam we jumped up as many as we could, may-be seven or eight. Twas a stiffish hill, but she went off like a little bird."

The Vivian family saw these things and determined to aid the young engineer, notwithstanding old Mrs. Paul's crying out, "Good gracious! Mr. Vivian, what will be done next? I can't compare one to anything but a walking puffing devil."

Trevithick and Vivian became partners over that Christmas dinner in 1801, and then started for London to secure a patent. Lawyers did not know what term would make a title nor what the thing could effect. Tramroad and railroad engines were already in the field, but this was different. Sir Humphry Davy, Count Rumford, and Davies Gilbert came to their aid. Rumford approved but confessed he could not understand it. However, Vivian went home satisfied, and wrote to Trevithick, who was staying at No. 1 Southampton Street, Strand, and learned all the news of the village during their absence.

The patent dated March 24, 1802, is the first high-pressure engine. It is not necessary to recapitulate the particulars of its construction in these days. He made a model of it, and by some means, not explained, this model reached honour; and was exhibited as a scientific curiosity.

Mickleham has a good description. "It exhibits in construction the most beautiful simplicity of parts, the most sagacious selection of appropriate forms, their most convenient and effective arrangements and connection, uniting strength wtth elegance, the necessary solidity with the greatest portability, possessing unlimited power, with a wonderful pliancy to accommodate it to a varying resistance. It may indeed be called The Steam Engine!" It had no resemblance to any predecessor. All the fifty years' improvements were thrown aside; a little inexpensive thing, it was a wonder to all.

The three drawings below are of the first Passenger Common Road Locomotive of Trevithick's, and the technical description is as follows:—

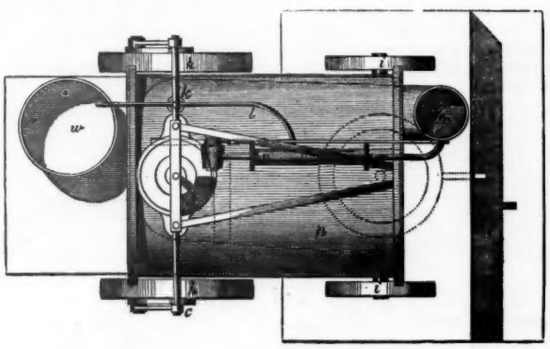


Fig. 5.

a, cylindrical boiler with wrought-iron ends, having inside it a wrought-iron tube bent as the letter **U**; *p*, the fire-place, in one end of the tube; *v*, firebars; *u*, fire-bridge; *x*, the ash-pit; *q*, the return flue leading to *r*, the chimney, the fire-door is not shown as it would confuse the drawing; *z*, the steam-gauge; *s*, safety-valve; *t*, soft metal safety-plug in top of fire-tube; *j*, the bellows, blowing air into the close ash-pit, fixed to the guide-stays, and worked by the arm of its moveable middle division connected with the piston-rod cross-head; *b*, steam-cylinder let into the boiler, having a close top and bottom, with pipe for conveying steam to and from the bottom, and also the skill for the fourway steam cock, and the steam-way from the boiler, all cast with the cylinder; *o*, a four-way steam cock worked by a rod from the cross-head, with two tappets striking the lever, *o*, up and down, and having a handle *o*, suitable for the engineman; *k*, the feed pole-pump, worked from the cross-head; *l*, the feed-pipe; *w*, feed-water cistern; *n*, case for heating feed-water by the passage of the waste steam through *m*, the waste-steam pipe, from the cylinder to the chimney; *c*, the cross-head; *f*, the two side rods; *g*, the two cranks; *h*, two driving wheels; *i*, two steering wheels; *e*, piston-rod; *d*, guides for the piston-rod cross-head.

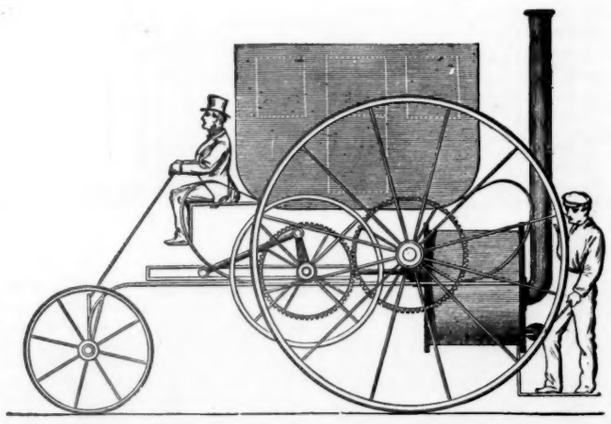


Fig. 6.

This is the work we think of great importance to a young engineer, and out of it came the Vivian and Trevithick's London Locomotive, which, in its turn, was superseded by that of 1803, wherein the cylinder was horizontal, the wheels larger, the bulk higher, the boiler of wrought-iron. This was harnessed at Fulton's Coach Factory, in Leather Lane, and Andrew Vivian did the driving up Gray's Inn Lane out to Lord's Cricket Ground, which is now Dorset Square, and then to Paddington, returning by Islington.

In a story combining anxiety, sorrow, and success, incidents occur that abound in humour. This little carriage has such association. Captain Joseph Vivian tells that his father, a

sea-captain, told him that being invited by Captain Trevithick and Captain Andrew Vivian—they were all captains in those days—to take a drive on their steam carriage—went along pretty well through a good many streets, but that the old captain fancied he had more danger of shipwreck on shore than on sea, he would not go again. Woolf, the engineer at Sir Henry Meux's brewery in Tottenham Court Road joined them, and one day they started about four o'clock in the morning, and went along Tottenham Court Road and the City Road: "there was a canal by the side of the road at one place, and wondered how deep it was," says Captain John Vivian, "for fear they should run into it. We were going on for four or five miles at the rate of eight or nine miles an hour. I steered, and Trevithick attended to the engine. Dick came alongside saying, 'She is going all right.' 'Yes,' I said, 'I think we had better go on to Cornwall.' She was going along five or six miles an hour, and Captain Dick called out, 'Put the helm down, John,' and before I could tell what was up, his foot was on the steering-handle, and we were tearing down a half-dozen yards of a garden fence. Then somebody put his head out of a window, exclaiming, 'What the devil are you doing there? What the devil is that thing?' They took the thing back to the factory and put it to rights."

Trevithick drove his steam-carriage through Oxford Street. The shops were closed, and from the windows of the houses handkerchiefs were waved, and no horses or carriages were permitted to pass during the experimental course. They drove through at a rattling pace amid the general cheering.

These were the first and firm steps of the young locomotive that Trevithick laboured to make mighty amid the scoffs and sneers of those who afterwards copied him.

We must not recite the history of embarrassing difficulties further, than to say that the little funds soon dissolved under this experimental period, and the poor steam-carriage was sold for what it would fetch. But Trevithick was not disheartened. He had the reality, of which Watt had only the shadow.

The Coalbrook-dale Company were building for him a new machine or engine. They did not like it, but they trusted the man. It was tried, and the high-pressure grew into favour. Watt's low-pressure vacuum was scotched. Trevithick writes, "Boulton and Watt have strained every nerve to get a Bill in the House to stop these engines, saying that the lives of the public are endangered, and an engineer from Woolwich and one from the Admiralty are coming to inspect and test whether the steam-gauges will admit steam, if the valve is fastened."

We need not say a word now about that. Watt failed; but won in fame and money. Trevithick won in science, but not in money. Boulton found the first in funds and diplomacy. For the latter there was nothing but his work. And it is the duty of our young engineers to see that he is honoured on that account.

His high pressure took its ten tons on common roads in a week. Homfray the goverment contractor gave up his coach, and that was the beginning of the Tram. *Englishmen should remember that Trevithick did this in 1803.*

Fig. 7. gives Trevithick's Tramroad Locomotive, and here is the description:

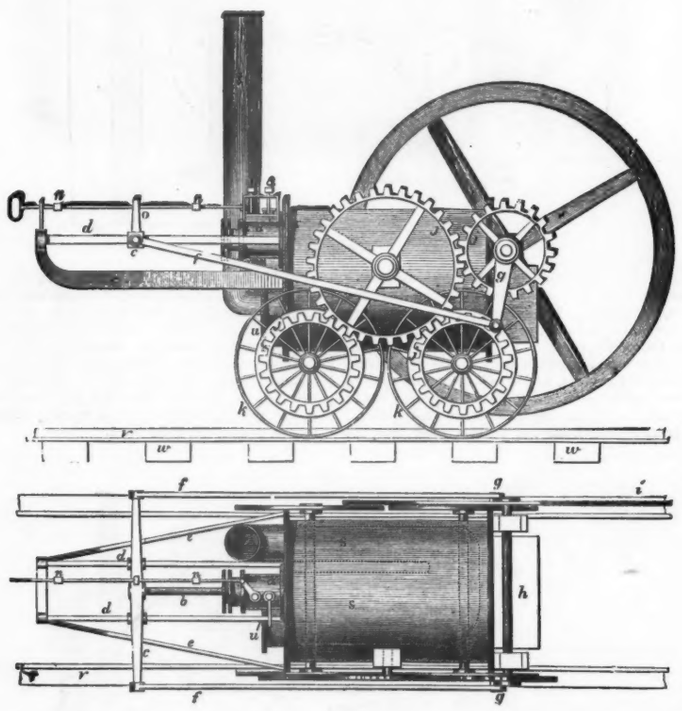


Fig. 7.

a, the cylinder, 8¼ in. in diameter, 4 ft. 6 in. stroke, fixed in the boiler; *b*, the piston rod, fastened to the cross-head *c*; *d*, the guides; *e*, the stays; *f*, the connecting rods; *g*, the cranks; *h*, the axle; *i*, the fly-wheel; *j*, the gear wheels; *k*, the drivers: *l*, the four-way cock; *m*, the lever; *n*, the working; *o*, the regulator; *p*, the same, and *g* also; *r*, the boiler; *s*, *t*, *u*, *v*, are mere factors in ordinary machinery.

All this is good for the young engineer to examine and study. It was merely an outflow of a full heart. "At my own expense," said he in 1874, "I made a travelling steam-engine. I chained to it four waggons, containing 10 tons of iron and 70 men, and it went from Merthyr 10 miles at 4 miles in the hour, *without the labour of man or beast.* When the load was off I went 16 miles an hour. I thought this experiment showed to the public quite enough to recommend it to general use; but, though a thing that promised to be of so much consequence has so far remained buried, I am discouraged from again trying its practice at my own expense." Looking at the business after the lapse of 70 years, we must blame our fathers for not perceiving the existence of a gifted and practical man who, in these later days, is recognised as the fountain spring that has blessed the world.

From the close of 1801 to 1805 half-a-dozen engines had been made, all having a blast-pipe, and thence occurs a jump of three years, during which Trevithick made a new locomotive, and a railway for the instruction of the London public.

Its wonderful simplicity exceeded that of Newcastle. Gilbert's sister gave it the well-known name "catch-me-who-can." Hawkins said of it in 1847, "I think it due to the memory of that extraordinary man to declare that in 1808 he laid down a circular railway in a field adjoining the New Road, near or at the spot of Euston Square. He placed a locomotive engine, weighing about 10 tons, on that railway, on which I rode, watch in hand, at the rate of twelve miles an hour. Trevithick gave his opinion that it would go 20 miles or more on a straight rail.

The engine was exhibited at a shilling admittance, which included a ride for the few who were not too timid. . . . . Mr. Trevithick having expended all his means, and the shillings not covering expenses, the engine was not again set on the rail.

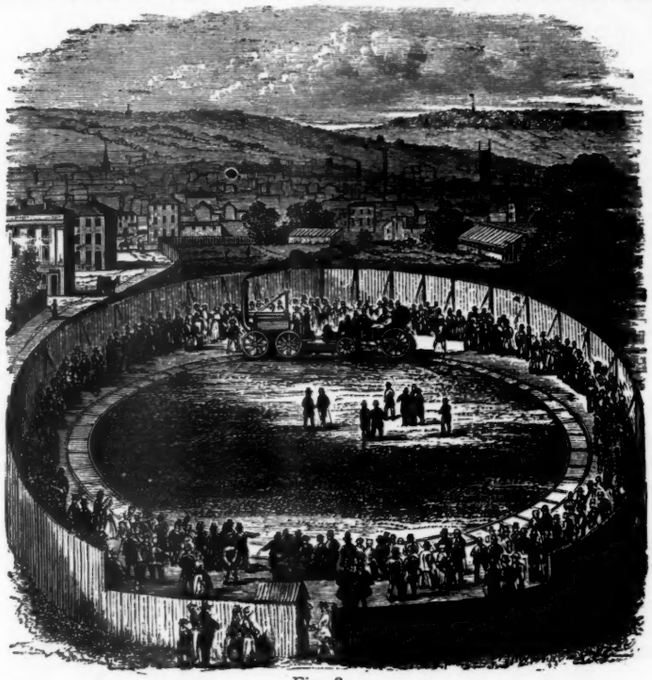


Fig. 8.

He who attempts biographical sketching of the lives of great men is oppressed by the wealth of matter, and somewhat affected with enthusiasm: it cannot be otherwise. He could not do his work faithfully under other conditions. We are obliged, nevertheless, to repress much, and probably more valuable matter, in order to make our story acceptable, and not to take too much space in its narration. Trevithick's influence and genius blessed and taught all it touched. Pumping, dredging, and engineering in every form claimed his labour. Rennie, Wyatt, Chapman, recognised his power, and Brunel owed something to his intelligence when the Thames tunnel arrangements were being made.

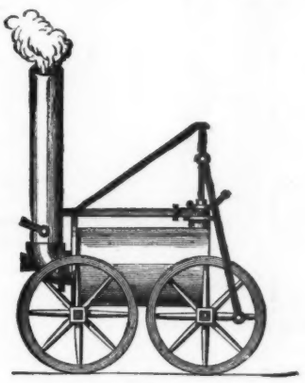


Fig. 9.

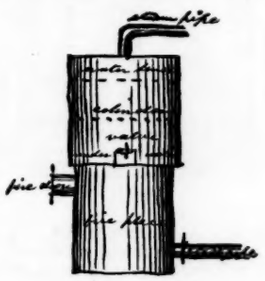


Fig. 10.

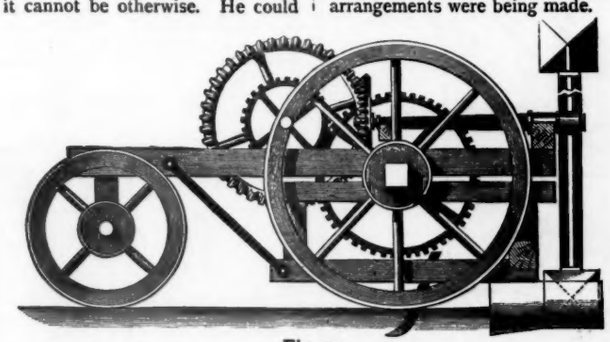


Fig. 11.

We will just refer to the miscellaneous work of Trevithick and close. He made in 1811 an aerated steam boiler (fig 9), out at that time several of his engines were at work in a dozen counties, and

in London alone another twelve. Founders were busy, for they sold in country places at £200 on average. They ground corn, dressed leather, worked the coal-mine, crushed the sugar-cane in the West Indies, and distilled rum, water-pumping, iron-rolling, locomotive rail-work, fire-engine power, and that of common cranes, and also of mines—all witnessed to the comprehensive genius and the practical labour of Trevithick.

The steam-boiler we illustrate is of singular value to a student. Hear what its author says—"Make an apparatus to condense and take the whole of the heat into the cylinder instead of its passing up the chimney. By having a very small boiler, and a blast cylinder, to blow the whole of the blast into the bottom of the boiler, under a cylinder full of small holes under the water, to make the heated air give all its heat to the water."

An engineer will see at a glance what this meant; it contained a revelation.

Writing to Sir Charles Sinclair in 1812, Trevithick says, "It is my opinion that every part of agriculture might be performed by steam." And he was as good as his word, for nothing ever excelled his spade-tormentor (fig. 10). The whole farming

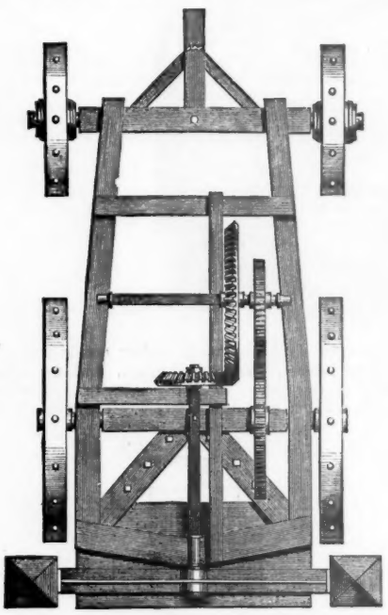


Fig. 11.

interest, where capital ruled, caught the idea, if they did not recompense the man. Agricultural machinery, in its present stage, is indebted to Trevithick for all its inspiration, or rather development.

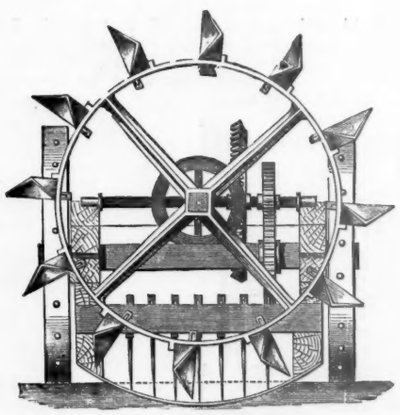


Fig. 12.

Hydraulics have been often referred to here, and will be again. Nevertheless, here we must not forget that wonderful Dolcoath 76-in. engine that worked for 54 years night and day, which Trevithick made. Here it is.

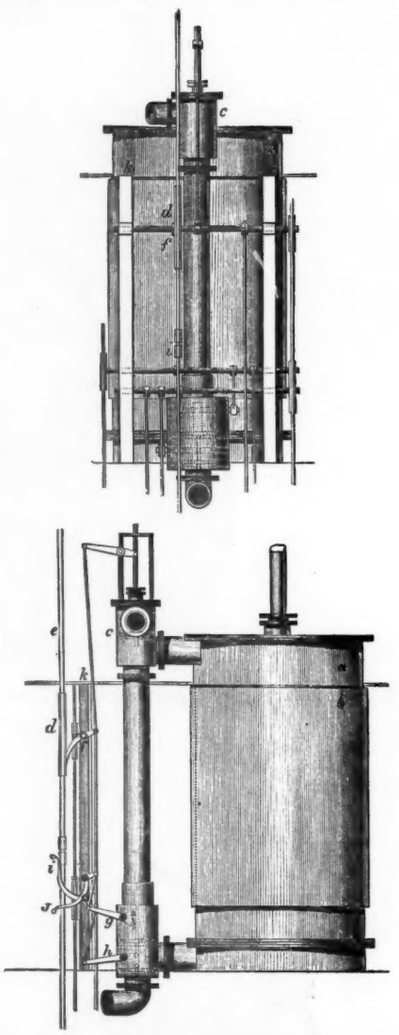


Fig. 13.—TREVITHICK'S PUMPING ENGINE, 1816, AND CEASED WORKING 1869.

a, steam cylinder, 76 in. diameter, 9 ft. stroke; *b*, steam-jacket; *c*, expansion valve, 11 in. diameter double beat; upper beat, 11 in. diameter, the under 9¾ valve 8 in. long; *d*, expansive Carn plug rod; *e*, plug-rod for moving the gear; *f*, expansive horn; *g*, equilibrium valve, 13 in., single beat, moved by a rack and segment; *h*, exhaust valve, 14½ in., lever and link; *i* and *j*, handles; *k*, Y-posts for carrying gear or box; *l*, main beam, two cast-iron plates; *m*, parallel motion; *n*, feed-pump rod; *o*, bucket rod, pump 33 in.; *p*, main pump rods. The cylinder is thus illustrated. (Fig. 14.)

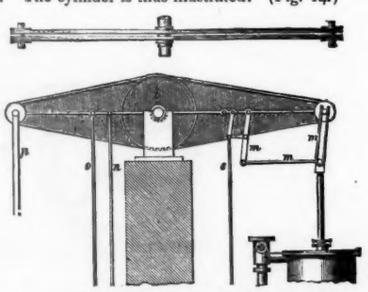


Fig. 14.—CYLINDER MAIN BEAM AND PUMP ROD, OR DOLCOATH 76-IN. ENGINE.

A man of this type could not be hidden. Orders came to him in very great abundance. He might have made a fortune had he the craft of money-making; that practical faculty did not belong to him. Among the many into whose society he came was Mr. Uville, and the circumstances are described by Stuart:

An enterprising Spaniard first conceived the idea of draining Mexican Mines by means of steam engines, and in 1811 visited London to acquire information respecting them. In England, however, he met with little encouragement in consequence of his inquiries being limited to the introduction of the atmospheric engines, which would act with a greatly impaired energy, in an atmosphere so rare as that in which the Peruvian mines are situated, added to an almost impracticability of conveying the parts which would be required for those large engines, over mountains inaccessible to any species of wheel carriage.

"About," says Mr. Boase, in a memoir inserted in the Transactions of the Cornwall Geological Society, "to leave England in despair of ever being able accomplish his grand project, on passing by a street leading from Fitzroy Square, Mr. Uville saw accidentally a small steam engine exposed for sale in the shop of a Mr. Roland. This was a working model which Trevithick had made of his high pressure engine, to give a better idea of its construction and action, and which being highly finished, was now exposed for sale as a cabinet curiosity. Struck with the simplicity and excellence of its principle and construction, Mr. Uville purchased it for twenty guineas, and felt that he had now the means of either carrying forward his scheme, or of setting the fever of his mind at rest, by satisfying himself by an experiment as to the possibility of achieving his project by the medium of the steam engine. Carrying the model to Lima, he hastened to try its power on the highest ridges of Pesco, which form the site of the mines. To his unspeakable joy, the experiment was perfectly successful. He now formed an association with two wealthy merchants of Lima, and under the patronage of the Viceroy, procured the privilege of working some of the neglected mines on condition of giving to the state a fourth part of the produce which might be brought to the surface. M. Uville again embarked for England, and during the voyage, conversing with a Mr. Fergus and expressing an anxious wish to find out the author of the model with which he first made his experiment, he was agreeably surprised to hear Mr. Fergus reply, 'that Mr. Trevithick was his near relative, and within a few hours after our arrival in Falmouth I can bring you together.' It happened accordingly, and M. Uville resided many months at Comborne, with Captain Trevithick, receiving instructions on the construction and management of machinery. They afterwards visited together the mining districts, and in their tour they came to Soho; M. Uville communicated to Messrs Bolton and Watt, the celebrated engineers of that establishment, the nature of his project, and enumerated some of its difficulties; above all the great elevation of the mines above the level of the sea, the mountainous precipices which were to be surmounted, and the absence of roads for the carrage of large masses in these extraordinary regions. Messrs Bolton and Watt discountenenced M. Uville's project; Captain Trevithick and his friend were not, however, to be discouraged from making the attempt; and within about six months Trevithick had constructed nine beautiful engines on his own admirable model, at a cost of about ten thousand pounds; which by very great exertions were shipped, with the permission of the British Government, from Portsmouth in the September following, accompanied by M. Uville and three Cornish men, to direct the erection of the machinery. On arriving safely at Lima, they were welcomed by a royal salute and public rejoicings. But after they had got so far, so great were the local obstacles in transporting the heavy masses across the mountains, that it was not till the middle of 1816 that they were able to set one of the engines at work. This was the first ever seen in South America, and excited intense curiosity. Great ceremony was observed on this important occasion, and the most distinguished honours were conferred on the projectors by the Vice-regal government. The official deputation appointed to superintend this new and very extraordinary operation made a report to the Viceroy, which was published in the Lima Gazette, in August 1816. Immense and incessant labours, and boundless expense, have conquered difficulties hitherto considered insuperable; and we have, with unlimited admiration, witnessed the erection and astonishing operation of the first steam engine. It is established in the royal military territory of Taüricocha in the province of Tarma; and we have had the felicity of seeing the drain of the first shaft in the Santa Posa mine, in the noble district of Pasco." They then go on to name a number of individuals on whom the eternal gratitude of all Spaniards is invoked, and it is somewhat remarkable that the only Englishman mentioned by name in this list of worthies is *Mr. Bull* of Chosewater, Cornwall; who was one of the three Cornishmen that accompanied M. Uville. While these operations were going on in Peru, Captain Trevithick in England was vigorously engaged in providing further supplies of steam engines, constructing coining apparatus for the Peruvian mint.

A second supply of engines, &c., was sent out in October, 1816, and arrived at Lima in the February following. Captain Trevithick went out in this vessel. On his arrival he was immediately presented to the Viceroy, and most graciously received, and his arrival officially announced in the *Lima Gazette*. Public notice was at the same time given in this of the completion of the second engine, said to be superior in power and beauty to the first; and also of the reception of some parcels of ore of extraordinary richness, raised from the mines restored to use by the operation of these machines. The *Gazette* also announces the arrival of the other engines; "but that," it continues, "which is of still greater importance is the arrival of Don Ricardo Trevithick, an eminent professor of machines, machinery, and mineralogy, inventor and constructor of the engines of the last patent, and who directed in England the execution of the machinery now at work in Pasco. This professor, with the assistance of workmen who accompany him, can construct as many engines as shall be wanted in Peru, without the necessity of sending to Europe for any part of these vast machines. The excellent character of Don Ricardo Trevithick, and his ardent desires to promote the interests of Peru, recommend him to the highest degree of public estimation, and make us hope that his arrival in this kingdom will form the epoch of its prosperity through the enjoyment of its internal riches, which could not be realised without such assistance; or if the British Government had not permitted the exportation from England, an object hitherto thought unattainable by all who know how jealous that nation is of her superior inventions in the arts or industry."

So much importance was attached to Don Ricardo Trevithick's personal superintendence, that the Viceroy ordered the Lord Warden of the mines to escort him with a guard of honour to the mining district, upon the news of his arrival in Peru caused the greatest rejoicings, and many of the chief men came to Lima, a distance of many days journey over the mountains to welcome him. M. Uville had written to his associates, "that Heaven had sent him out for the prosperity of the mines, and that the Lord Warden had proposed to *erect his statue in massy silver*."

Trevithick went out to Peru and entered into business

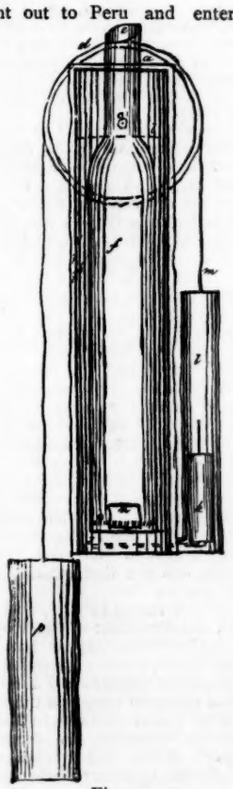


Fig. 15.

arrangements with the government there, concerning engines, mixing himself so imprudently with money contracts, shares, and

the like, after the custom of his country. He became a partner to Uville, paid £3000, obtained nothing for his engineering, and after all the speculation turned out valueless. Disasters followed. His Cornish friends backed him up to £13000 and lost all; Uville was arrested, and in a short time quarrels arose that are of no other use to us than to show Trevithick's incompetency for business, and to exhibit the great loss of time and strength that might have had a richer return. He was able to do wonderful work, nevertheless, and his name in Peru and Costa Rica is famous to this day.

Robert Stephenson met him at Carthagena, in the time of his dark fortune, and generously enabled him to return to England. "Bobby," said he, "I nursed as a baby boy, and he helps me to go home." There was, it appears, some want of cordiality, notwithstanding, whether from professional jealousy or temperament we do not know. Stephenson, we know, had a £100 note, and gave Trevithick half of it in his distress. They have both left us, and we imagine the difference to be quite as likely Trevithick's temper as Stephenson's jealousy.

We find him busy with gun carriages, iron ships, hydraulic cranes, ice-making, draining, pumping, engineering, and then returning to his steam boiler cares.

Trevithick pointed out that cold on the surface of the steam-case of a Watt low-pressure steam vacuum engine, condensed about one fifteenth of the steam given from the boilers, and that the loss from exposure to cold was nearly five times more from high-pressure than from low-pressure steam. He determined in 1829, on constructing an engine to test these views. A terrible fight ensued in the trial, for the companies were rivals, and the question had a vital character. The sketch, fig. 15, he sent to Mr. Gilbert, with a long description in which he said, "The engine is for the express purpose of experimenting on the working of the same steam and water over and over again, heating the returned steam by passing it in small streams up through the hot water from the bottom of the boiler," . . . "which will have a great number of small holes. The steam delivered, I should think, will pass up when delivered into the boiler through the hot water and regain their usual temperature." These experiments will, I think, throw more light than has ever been done on this subject. The engineer will see how Trevithick had constructed his by the reference :—

a, top of boiler; *b*, water line; *c*, centre of wheel; *d*, cast-iron wheel and chain; *e*, chimney, 13-in. in diameter; *f*, fire-tube, 2 ft. in diameter; *g*, outer-boiler case, 3 ft. diameter, 15 ft. long; *h*, water space of 6-in.; *i*, boiler steam-case, 3 ft. 4-in. diameter; *j*, the small holes; *k*, force-pump, 10-in diameter, 2-ft. 9-in. stroke; *l*, steam cylinder, 14-in. diameter, 6-ft. stroke; *m*, piston rod; *n*, fire-door; *o*, fire-bars; *p*, testing-pump.

The object was in the experiments to employ high-pressure steam in the boiler, using it very expansively in the cylinder, and by cold surface sides reducing its bulk either to low-pressure steam or boiling water, and thence force it back again into the boiler. This invention of a condenser dates from 1802, but was not patented, and he wrote in 1830 to the Admiralty under the endorsement of Mr. George Rennie, and Mr. Gilbert, asking the loan of a vessel of 200 tons, on which he could fix his apparatus and prove that he could do without sea-water. The sketch is more ingenious than any portable engine since constructed, and the propeller was his long-idle screw. He took his patent in 1831, and why? In the early part of this paper we have his increasing steam-pressure, in 1796, and Mr. Watt's condemnation of what is really the only good system; improving it in 1796, 1811, 1815, 1828, and it passes all understanding how Mr. Smiles should endeavour to attach the names of Messrs. George and Robert Stephenson to what was done in that eminent gentleman's boyhood. Trevithick's patent of 1802 has a three-tubed boiler before Evans or Fulton began their experiments, and Stephenson's Killingworth boiler is only a reproduction. Mr. Francis Trevithick, the writer of the memoirs of the Trevithicks, had an engagement from the government in 1831 to apply these, and he declares they were practically the same as those his father had made from 1801 to 1828, and had served the locomotives in England, and the first steam-boat experiments in Great Britain and America.

When his health was failing in 1831, and the application to government urged, the President of the Royal Society added that the power of the Watt engine had been trebled by Trevithick. It would not prevail. He in his old age, although in no way political, caught the Reform Bill fever, and there is in his writing what was meant to appear in the *Morning Herald* of July 1832, his proposal "to commemorate that event by erecting a stupendous column, exceeding in dimensions Cleopatra's Needle, or Pompey's Pillar, and symbolical of the beauty, strength, and unaffected grandeur of the British Constitution. The Dukes of Norfolk and Somerset, Earl Morley, Lord Stafford, Sir J. Burdett, Messrs. Joseph Hume, R. H. Howard, W. Brougham, J. E. Denison, A. W. Robarts, J. Easthope, and General Palmer, members of Parliament, lent their names. We refer to it as a proof of his engineering versatility, and power, and in Fig. 16 is the plan, and sectional elevation of this.

"Gilded conical cast-iron monument of 1000 ft. in height,

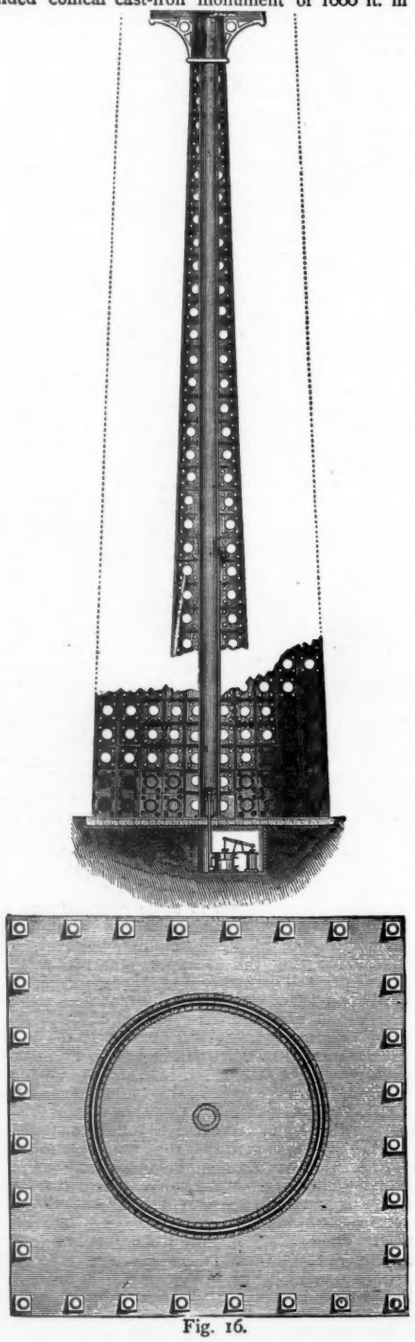


Fig. 16.

100 ft. diameter at the base, 12 ft. at the top, 2 in. thick, in 1500 pieces of 10 ft. square, with an opening in the centre of each piece 6 ft. dia., and in each corner one of 18 in. diameter, for lessening the resistance of wind and lightening the weight; flanges on every edge inside to screw them together; foundation of circular stone, and an ornamental base column of 60 ft. high, as seen in sketch, Fig. 17 in which is contrasted St. Paul's, the Pyramids, and of course, the work had to be performed by the aid of a 20 horse high-pressure steam engine. His biographer writes justly:—

"To Trevithick's soaring genius, nothing appeared very large, very small, or very costly; not even the cast-iron column 1000 ft. high covered with gold. The stone monument of London is 210 ft. and is admired by many; others climb to the top of St. Paul's 420 ft., and some make a long journey to mount the Pyramids, a height of 500 ft. How much more pleasant would be Trevithick's, floating 1000 ft. upwards on an air cushion, and from the loftiest pedestal of human art survey London, lowered again to terra-firma safely, by valves that closed by such simple acts as rising from the seat. Delay followed, and before two months from the date of his design, Trevithick passed away. His family received a note from a friend at Dartford, April 22, 1833, that he died that morning, after a week's illness. He was penniless, and without a relative, for the last kind offices were administered by friends who were losers by his schemes.

The last years of Trevithick's life were chequered with hopes and disappointments, and he applied for pecuniary help to the Government of the day. His health was rapidly failing, and his mind much distressed by the neglect he felt to be undeservedly his portion. We find him making a curious proposal to erect a Reform Column to perpetuate the passing of the Reform Bill in 1832, a measure that has been superseded by others and excited more hopes than it satisfied. This is his plan as addressed to the *Morning Herald*, July 11, 1832, and fig. 16 and 17 are the illustrations.

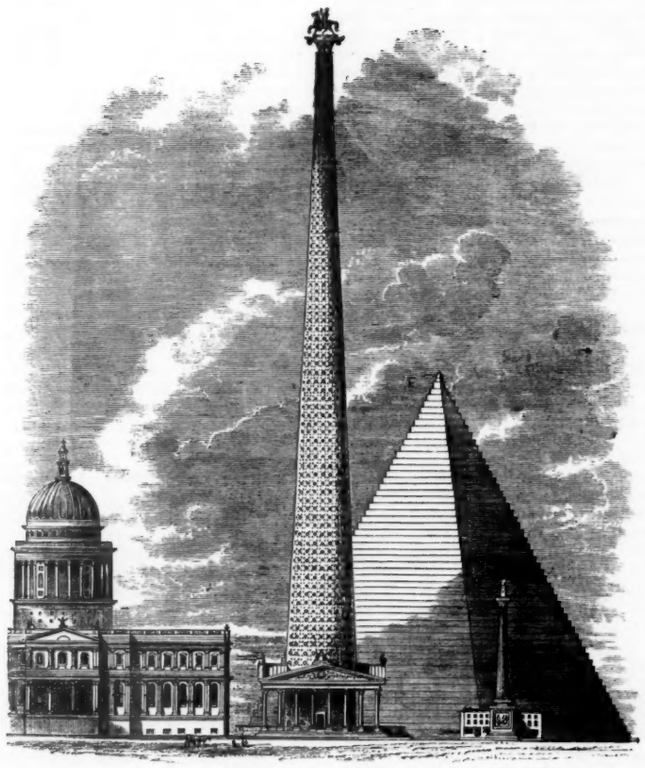


Fig. 17.

His comprehensive and ingenious designs, given to the world seventy years ago, are still instructive guides, and many of his works, dating from the dawn of the present century, remain as active evidences of his skill almost to the present day, with their three-score years, while some few reaching three-score years and ten are still good servants in the solitude of the Peruvian Mountains, where no mechanical hand repairs the errors of human skill or the wear and tear of time. If these material proofs fail to convince, the reader has but to ponder on the bitterly natural reflections written by himself, a few months before his last illness, to his friend, Davies Gilbert:—"I have been branded with folly and madness, for attempting what the world called impossibilities, and even from the great engineer, the late James Watt, who said to an eminent scientific character, still living, that I deserved hanging for bringing into use the high-pressure engine. This so far has been my reward from the public, but should this be all, I shall be satisfied by the great secret pleasure and laudable pride that I feel in my own breast from having been the instrument of bringing forward and maturing new principles and new arrangements of boundless value to my country. However much I may be straitened in pecuniary circumstances, the great honour of being a useful subject can never be taken from me, which to me far exceeds riches."

THE ECONOMIC USES OF FLOWERS.

By P. L. Simmonds.

Of the various parts of plants used industrially the flower would seem to be that of least importance, and yet this enters more than would be at first supposed into commerce, and many flowers are of the greatest importance to the perfumer and dyer. Not to speak of the trade in cut flowers and flowering plants, and the extensive commerce carried on in these in great cities, and passing over a considerable branch of trade in what are known here as "everlasting flowers" and "immortelles" on the Continent, an acre of which plants will yield two or three tons weight of tufts of flowers, realising from 12s. to 16s. per cwt.: a few details may be given serving to illustrate the commercial value and various uses of flowers.

Among the most important products in a commercial point of view are safflower, saffron, rose leaves, lavender, pyrethrum, orange blossom, cassie flowers, violets, jasmine, tuberose and camomile flowers.

Safflower, from the deep orange petals of the *Carthamus tinctorius*, is obtained in parts of Southern Europe, India, and China, the latter being considered the best. The imports of

safflower into this country vary considerably, having reached as much as 32,000 cwt. in some years, but in the last two years our supplies have dropped to about 3,000 cwt. The great centre for the use of this dyestuff appears to be Lyons, where it is employed to dye silks and satins.

We also import from 3,000 to 5,000 lbs. of extract of safflower, worth from £1,000 to £1,760. The exports of safflower from India exceed in value £100,000, and from China, they are about the same amount, to say nothing of the local consumption in Asia and the produce in Southern Europe.

Saffron is obtained from many countries, but the preparation is chiefly confined to France and Spain. The total value of the saffron produced annually is estimated to amount to one million sterling. About 30,000 flowers are required to produce 2 lb. of fresh pistils, which when dried are reduced to one-fifth of that weight. Pereira says it takes nine flowers to make up a grain of marketable saffron, so that it would require no less than 4,320 flowers to yield 1 oz. Some, again, assert that to produce 1 lb. of dry saffron 107,520 flowers are necessary, while others put the quantity as high as 203,920 flowers. According to Dumesnil, in the *Académie des Sciences*, 7,000 to 8,000 flowers are required for yielding 17½ozs. of fresh saffron, and this weight, as already stated, is reduced one-fifth by drying.

Our imports of saffron are, compared with its use on the Continent, not very large. They were :—

	lbs.	£
In 1867	9,401	17,963
" 1868	26,048	50,198
" 1869	22,152	36,596
" 1870	43,950	95,690

The imports into this country have not been published since then. The largest quantity comes from Egypt (nearly half), then follow the supplies of Spain and France, varying in quantity according to crop. Judging by prices, the Spanish would appear to be held in less estimation than formerly.

Very extensive rose farms exist at Shiraz, in Cashmere ; at Ghazepore, in India ; at Adrianople, in European Turkey ; at Broussa and Uslak in Asiatic Turkey ; and about Cairo and other parts of Egypt. It is said to have been the Princess Nour-Djihan who discovered, at the commencement of the sixteenth century, the essence of roses in the empire of the Mogul, and received for this a necklace worth £3,000. In 1611 the Sultan Ahmoud I. sprinkled the pavement and the interior of the new Kasbah with jets of rose water. It is also said that Saladin, after the Peace of Jerusalem in 1187, sprinkled the Mosque of Omar with rose water from Damascus. The odoriferous rose was formerly cultivated in the oasis of Fayoum, Middle Egypt, but the culture has been almost abandoned. The essence used locally there is now chiefly obtained from the ordinary roses of the country, collected in spring in the gardens.

Experience has shown that for every ounce of attar of roses 3,000 lbs. of rose leaves are required.

The yearly production of the districts in the province of Kezanlik is on an average 3,500 lbs. Some years, however, the bushes are exceptionally prolific. Thus in 1866, 6,000 lbs. were produced, but in 1872 only 1,700 lbs. could be obtained. The war now raging in this district has, however, made sad havoc with the rose gardens, and for a time destroyed the produce. The pure attar, at 30s. per ounce, yielded an income of £84,000 yearly to Roumania. Of rose leaves we imported—

	lbs.	£
In 1867	8,775	476
„ 1868	5,323	267
„ 1869	6,427	321
„ 1870	8,382	420

Since that year there has been no official return published.

The leaves are usually imported salted: 1 lb. of salt well mixed with one bushel of roses (6 lbs.) converts them into a magma (pickle). As their primitive odour is preserved they can be distilled at any time, and produce as good rose water as fresh roses. The Provence rose will yield in the second and third year from one or two hundred bushels of roses per acre. The damask rose is that chiefly cultivated for medicinal purposes. Just before the bud is about to open it is plucked, and the bottom of the bud is cut off. These cuttings are termed " rose heels ; " the top is preserved either to make infusion of roses or conserve of roses.

M. Piver some time since published the following statistics of the flowers employed in perfumery annually produced in the department of the Alpes Maritimes :—

	Kilos.
Roses	904
Orange flowers	61,218
Jasmine	62,500
Tuberose	18,200
Cassie or Acacia	35
Violet	86

The yield of flowers per 1,000 metres (not quite a quarter of an acre) he gave as follows :—

	No. of Plants.	Flowers.
Roses	1,200	300
Oranges	25	250
Jasmine	3,500	130
Tuberose	17,500	500
Cassie or Acacia	750	750
Violets	—	200

The lavender fields in the London district cover about 500 acres, and the yield of essential oil varies from fifteen to thirty pounds weight per acre, according to the season or age of the plants. These are chiefly by Tooting and Mitcham.

The little bouquets of violets which are generally sold in the streets of London are the produce of many acres of land at Mitcham and its neighbourhood. On one farm there are 16 acres of land under violet culture. The two varieties of this flower principally grown are the Russian and the Giant. The first-named is darker in the colour, and often scented by art ; and the later is the most fragrant—the English. There are large violet farms in the South of France, near Nice.

Several species of *Pyrethrum* are grown in parts of Europe—*P. carneum*, *roseum*, &c—for their flowers, which are very obnoxious to insects, and are sold when powdered under the name of Persian or Caucasian insect powder. In 1870 these flowers were exported from Ragusa to the value of £1,104. That from the Caucasus is the best. The amount of this powder consumed annually in Russia is said to be about 500 tons. A quantity of these plants, grown upon 18 square rods, is estimated to furnish nearly one hundred weight of powder, which is best preserved in closed vessels of glass. As generally sold, the powder is very much adulterated and worthless, often mixed with sumach. A good insect powder ought to stupefy a fly in one minute if four grains are sprinkled on it in a vial, and death should ensue in two or three minutes. Some of the commercial insect powders, however, require fifteen to thirty minutes to kill a fly.

Incidental mention may now be made of some of the other uses of flowers at home and abroad.

The medicinal substance called semen-contra is obtained from plants belonging to the family of Composites : according to Batka it is yielded chiefly by *Artemesia Sieberi*, Besser. The flower-head is the part of the plant employed. Santonine, the active principle of the drug, is valued as a vermifuge.

In France the flowers of *Malva sylvestris* and *rotundifolia*, and of *Althæa officinalis*, *Nymphæa alba*, *Verbascum Thapsum*, *V. lanatum*, and *V. nigrum*, are officinal, emollient, and demulcent, furnishing a pure mucilage.

The marsh mallow is cultivated in certain districts of England, and held in repute as a medicinal plant, being used chiefly in fomentations and gargles, and in homœopathy.

The flowers of the well-known marigold (*Calendula officinalis*) were formerly used in soups and broths and as a carminative, but they are now chiefly employed to adulterate saffron.

The flowers of *Lyperia crocera*, of South Africa, resemble true saffron in smell and taste, and have similar properties : yielding a fine orange colour, they have been imported into this country for dyeing purposes. The flowers are in daily request with the Mohammedans at the Cape, who use them for the purpose of dyeing their handkerchiefs. They possess similar properties to saffron, and as an anti-spasmodic, anodyne and stimulant, according to Dr. Pappe (*Flora Capensis*) ought to rank with the *Crocus sativus*.

The flowers of the yellow ladies' bedstraw (*Galium verum*) have been used in England in the place of rennet to coagulate milk.

Saffron flowers and those of the Embuch are employed for dyeing in Turkey. Those of *Althæa filicifolia*, Cav., are used in Turkestan to form cataplasms for inflammatory swellings.

The extremely fragrant flower-heads of *Santoline fragrantissima*, Forsk., are sold in the shops of Cairo as a substitute for camomile, under the name of Babouny or Zeysoum.

An infusion of the dried blossoms of the common cowslip is drunk in some counties in England under the name of cowslip tea. The blossoms communicate an aromatic fragrance to home-made wines, resembling that of the Muscatel wines of the south of France.

An infusion of the flowers of the line (*Tilia europea*) separated from the bracts, is considered to be a sovereign remedy for headache in Switzerland and Germany. The flowers of the *T. argentea*, Desf., have been met with in Europe as a substitute for the flowers of *T. parviflora* and *T. grandifolia*, Ehrh. The flowers of the former species have larger bracts, which are of a greener colour than the officinal, finely reticulated above, and underneath densely covered with stellate hairs, which readily separate when dry, forming a woolly, irritating powder ; the flowers have, particularly in the fresh state, an odour reminding of hyacinth and lily of the valley.

An infusion of the flowers of the linden is much used on the Continent, being considered good in vertigo and spasms, and against coughs for its expectorant properties.

In North America *Calycanthus lævigatus* and *C. floridus* are much prized for their highly-scented, inconspicuous flowers, which are often gathered and put into clothes drawers to impart their perfume.

Evodia hortensis is a favourite plant in the gardens of the natives of the Pacific Islands, being used for scenting cocoa-nut oil.

The small flowers of *pandanus odoratissimus* are very fragrant, and from them an oil, known as keora oil, is obtained. The perfume is extracted chiefly from the male flowers. The floral leaves themselves are eaten either raw or boiled.

The flowers of a jasmine, the *Nyctanthes arbor tristis*, shed a delicious fragrance in gardens, where they bloom only during the night. It is at sunset they open, and before the morning the ground is covered with the fallen corollas. The native women collect them in India, and, stringing them on threads, wear them as necklaces, or twine them in their hair. The orange-coloured tubes dye a beautiful buff or orange colour, with the various shades between them, according to the proportion and mode of conducting the operation, but no way has yet been discovered of rendering the colour durable.

In the east the petals of the flowers of *Hibiscus rosa sinensis* are used for blacking shoes, and the women employ them to colour their hair and eyebrows black. They are also eaten by the natives as pickles. The flowers are used to tinge spirituous liquors, and the petals, when rubbed on paper, communicate a bluish purple tint, which forms an excellent substitute for litmus paper as a chemical test. In China they make these large handsome crimson, yellow, and white flowers into garlands and festoons on all occasions of festivity, and even for their sepulchral rites.

The flowers of *Acacia farnesiana*, known as cassie, distilled, yield a delicious perfume. In Borneo the fragrant flowers of *Areca Catechu* are mixed with medicine for the cure of many diseases.

In China many odoriferous flowers are much used in scenting teas. Ball, in his work on "Tea," pp. 162-164, gives a description of some. Among these the following may be enumerated:—The best kinds of Caper or Sonchy teas are said to be scented more or less with the curious green flowers of the Chu-Lan (*Chloranthus inconspicuus*, Swartz), although Fortune states that those of the *Aglaa odorata*, Lour., are used. These writers agree, however, in the following:—

Pac-sheen, the sweet-scented pale yellow flowers of *Gardenia florida*.

Quy-fa, or Kuey-noa, the yellow flowers of *olea fragrans*.

Moo-ly-Hoa, the white flowers of *Jasminum Sambac* and *J. paniculatum*.

For the cowslip-flavoured teas, the pink flowers of *Primula pœnitens* are employed. Orange blossoms and many other flowers are believed to be used, but they should always be full blown.

The *Mesua ferrea* is much cultivated in Java and Malabar for the beauty and fragrance of its large white flowers. When dry they are mixed with other aromatics, such as sandal-wood, and used for perfuming pomades. The blossoms are found in a dried state in the Indian bazaars, and are called Nagkushur; they are used medicinally, and much esteemed for their fragrance, on which latter account the Burmese grandees stuff their pillows with the dried anthers.

The large flowers of *Michelia Champaca* are celebrated for their exquisite perfume, and the tree is highly venerated by the Hindoos. The natives adorn their heads with them, the rich orange colour of the flowers contrasting with their dark black hair. Sir W. Jones states that their fragrance is so strong that bees will seldom, if ever, alight upon them.

Large numbers of the fleshy variegated calices of the *Hibiscus Sabdariffa* are dried and stored in parts of Africa; in this condition they retain their fragrance, and serve for the purpose of giving the soups of the natives an acid flavour almost as sharp as vinegar. The calyx and capsule, freed from the seeds, make excellent tarts and jellies; a decoction of these, sweetened and fermented, is commonly called in the West Indies sorrel drink.

The natives of India are very fond of the flowers and leaves of *Clerodendron serratum*, which they eat as vegetables.

From the flowers or blossoms of the red gum tree (*Eucalyptus rostrata*), the natives of West Australia make a favourite beverage by soaking the flowers in water. The *Banksia* flowers are also steeped to extract the honey. The natives are extremely fond of the infusion, and in the season their places of resort may be recognised by the small holes dug in the ground, lined with the bark of the tea tree, and surrounded with the drenched remains of the flowers, called by them man-gyt. They sit around this hole, each furnished with a small bunch of pine shavings, which they dip and suck until the beverage is finished.

From the flower of the Budjan shrub (*Dryandria Fraseri*), a nectar or honey is also obtained, much sought after by the natives.

STEEL, IRON, AND COAL REVIEW.

EVERY indication that is recognised by men of experience as being worthy of regard, points to a revival of these great industries, in which vast capitals are employed, thousands of men engaged, and upon which the commercial greatness of England does seriously impend. Time of distress followed that of prosperity, and that is a universal law; wages at champagne height, and out-puts past all reckoning, can only end in the scale being turned too much below, to rise to the proper average. We see that result is being brought about through pain, loss, and sorrow; and we wonder at the absence of sympathy between the various persons engaged in that line of life. The miner, the proprietor, and the merchant, have separate and antagonistic interests; but when their especial troubles interfere with general convenience, and involve particular oppression, the public expresses the annoyance it feels. The public takes no sides. Merchant, miner, or proprietor represent in terms, various sides of social tribulation, each of which has interests in common, and they must contrive in combination to evolve harmony, or else accept the public indignation and the public contempt.

Steel-rails are looking up. They must. Brown, Cammell, the new firm Brown, Bayley and Dixon, Wilson and Cammell, Fox, Steel, and another Cammell are busy. Eight firms of great production in a satisfactory state, is a fact that needs no adornment. Six months contracts are abundant, and for English rails that run to money, our local steel mills are turning out 6000 tons weekly.

Springs and buffers are a very quiet trade. You have only to look at any station, anywhere, and see the mass of profitless engines, and the hundreds of idle carriages, and then imagine what is the condition of one of the best departments.

But amid all the grumbling, there is the fact of new works being started, and with a warranty of success that rebukes the general croaking. Wales is looking up. The ore is good; that is a fact well known among the geological section of mine managers. By mixing, there can be produced as good an iron for mechanical purposes as can be required. It can be bent, like that we had a drawing of some 12 months ago, and will not fracture when the two ends meet. Surely the principality need not dread the extinction, which it is idly supposed Scotland would inflict. There is room enough here: our duty is to arrange the interests of the labourer and capitalist to a unity; and then although France and Belgium, and even Germany be full of coal—as we know they are—if we are "to ourselves but true, we shall not fear the face of any other man."

The spirit of Scotland in the coal and iron trade is most gratifying. The coal owners employ all they can, and will not cause short time if it can be avoided. The iron workers on the Clyde works who were on strike, to the number of 1000, have gone back by a conference which ended in the adjournment of the future for six months, to their old wages, after twenty-seven weeks of idleness.

In Lancashire there is a slackness in the steel trade, because buyers are chary of giving orders; but the makers have satisfactory supplies of orders in hand. It will be "all right" before Christmas, both for masters and for men. Engineers and iron founders are not fully employed, but they are doing an average trade at more than average prices.

One cannot but note the recent observations in our public journals about over-production. Somebody who is an M. P. had the chair, and the meeting passed a resolution that over-production was the cause of the present low wages. What was to be done? And what do you think was done? They discussed whether the delegates should meet again in three months, and consider whether over-production should be reduced by "*migration, emigration, or by curtailment of the out-put of coal per man.*" No resolution was arrived at. We should think not. Migration hurts their brethren; emigration hurts themselves and their country; and as for the out-put, get up all you can, and don't be idle.

Social matters of this character demand the free expression of opinion, and must be accepted in the temper in which they are offered; viz.,—the desire to explain matters of difference, and to unite those who ought not to be disunited. It must be plain that

migration, and emigration, and starvation involve absurdities which if men put to the test, will be found extremely perilous. The causes are deeper. Excessive prosperity has produced excessive adversity, and we must endure what is necessary in the process of averaging.

Mr. Macdonald has in these hard times spoken, as he often does, words of boldness and truth. He maintained at one of these protection meetings, that in regard to the whole world the iron trade of England is in a much better state than that of any other nation. He said the same in reference to the coal trade. But he used the argument that because we were best off, we ought to stop over-production; and that we think, is cutting off the nose to avenge the face.

It is curious to notice the vitality of the Bessemer process. We have continuously to observe the operation of rivals, Cleveland or otherwise; but the general trade declares that Bessemer iron is in liberal consumption by makers of steel, and that forge qualities which have occupied an unsatisfactory postition for some time, are selling freely; and those best qualified to offer an opinion, believe that the new year will bring increased activity and better prices. This is confirmed by the fact that masters are determined to hold on, maintain production, will not accept lower rates, &c. They are supposed to know the value of their stock, and when they resolve to hold on, we may be pretty sure that the instinct pointing to better times is worthy of respect.

Coal has a like position in the market. Coal-owners enforce reduction, but in doing so will not discharge their men. They too have a presentiment that better times are coming wherein both men and master will gain at possibly the public cost, but that is inevitable in all trading and in all production. The emigration of colliers has throughout the autumn been continuous, especially towards Russia, where there are immense coal fields untouched, and where the overseers from England can have on new enterprises £200 a year.

We have in constant succession the regrets about our people going to foreign countries in order to better their fortune, and are utterly unable to discern their justice. It is a loss to a great firm where the overseer of a department quits his position; but life is constant change, and, moreover, death is certain. In all such cases there is of necessity some one close by who can take up the duty, and if the business has been properly ordered carry on the works without any perceptible interruption. A much graver difficulty arises from the abuse of the right of combination, whereby the cost of production is enhanced so greatly as to disable the British capitalist from competition in great works, and thus orders go to America, Belgium, Sweden, and even Russia. We should adapt our policy and conduct to the circumstances which surround us, and not attempt heroics that only yield misery and ruin. If a class, whether manufacturers or workers, chooses to refuse submission to market values they alone are the losers, for the trade goes away. If the trade goes the wisest of the producers will follow it: they are determined to live and to work, for they want money to sustain all that makes life worth having; and if that supply cannot be had except by obstruction, they will go where it can be had. So with the capitalist. Many of our strong houses have branch establishments abroad which would never have been but for this hard line of fact and circumstance. Prohibitive duties, or the tyranny of the labourer, have compelled such proceedings and until the folly is eradicated, the capitalist carries his money to another market, for he too wishes to increase his wealth.

THE USE OF BLAST IN GAS REVERBERATORY FURNACES.

IT is well known in ironworks that, whenever a good steady breeze of wind sets into the ashpit of a common puddling furnace, the action of the fire and working of the furnace are both improved. On the other hand, with a breeze in the contrary direction, the result is quite opposite. It was therefore a natural idea, in spite of the conservatism of ironmakers, that the action of the wind should be attempted to be imitated by applying a cold blast beneath the grate. Accordingly, a certain number of such furnaces—not many—are worked with a blast beneath the grate, sometimes with a closed ashpit. Some thirty years ago it was attempted to apply not merely a cold blast, but even heated air under a pressure. The result was a failure; the evil effect was found in that the combustion was so intensified on the grate that the furnace itself was actually cooled down. Another kind of injury was induced by the attendant blowing of the deleterious ashes over on to the bed. And yet the use of blast in itself ought to be a gain! It cannot be calculated that a pound of coal expended in doing work in a steam-blowing engine, or even a fan, will do more work than something like 500 times as much coal consumed in heating a column of air in order thereby to expand it sufficiently to enable a chimney to act as an exhaust apparatus. But such an exhaust apparatus is essentially deficient, as its capability of sustaining the combustion is dependant upon the energy of the combustion itself. Many people fondly imagine that the absence of smoke at the mouth of the stack is in itself a proof of complete and economical combustion. But this absence of smoke may be simply due to the mixing of carbonic acid gas at a red heat with the carbonaceous particles. The resulting carbonic oxide is transparent and colourless; but its escape means a waste of fuel. Any heating apparatus is all the more perfect the more thorough the combustion with the minimum quantity of atmospheric air. Almost all tests of the fire gases issuing from any stack show that the atmospheric air is therein present to excess. This excess lowers the temperature of the gases of combustion, uselessly conveys away quantities of heat, thereby unnecessarily incerases the surfaces of the apparatus to be heated, and the cross sections of the channels for the flame, with further attendant losses. Instead of applying the wtste gases to obtain a draught, a more scientific and remunerative mode consists in abstracting some of this heat in warming up the oxygen and its diluent nitrogen required to sustain the combustion of the fuel.

There is a curious physical phenomenon connected with combustion which directly points to the use of blast wherever practicable. It is the absolute necessity for an excess of air if only a draught, and especially a weak draught, be employed. The amount of air required for actually burning coal is to be estimated at 12 lb. per pound of fuel; but for the dilution of the fire gases that would otherwise prevent free access of air to the fuel, at least 6 lb. more of air are generally necessary, even in the favourable case when an air blast is used. When only chimney draught is employed, double this amount, or 24 lb. per lb. of carbon, are often required. As illustrating the principle of dilution, Dr. Frankland's experiments on Mont Blanc, as cited by Dr. Tyndall in his treatise on heat, may be quoted:—"Six candles were purchased at Chamouni, and carefully weighed; they were then allowed to burn for an hour in the Hotel de l'Union, and the loss of weight was determined. The same candles were taken to the summit of Mont Blanc," where the atmospheric pressure would be about one-half less, "and in the morning were allowed to burn for an hour in a tent, which perfectly sheltered them from the action of the wind. The aspect of the six flames at the summit surprised us both. They seemed the mere ghosts of the flames which the same candles were competent to produce in the valley of Chamouni. Pale, small, feeble, and suggesting to us a greatly diminished energy of combustion. The candles being carefully weighed on our return, the unexpected fact was revealed that the quantity of stearine consumed above was almost precisely the same as that consumed below. Thus, though the light-giving power of the flame was diminished in an extraordinary degree by the elevation, and consequent tenuity of the air, the combustion was the same above as it was below. This curious result is to be ascribed mainly to the mobility of the air at this great height. The particles of oxygen could penetrate the flame with comparative freedom, thus destroying its light, and making atonement for the smallness of their number by the promptness of their action." The two savants evidently and naturally at first expected that, in the rarefied air and diminished atmospheric pressure on the top of the mountain, the diminution of oxygen would proportionately lessen the intensity of the combustion. An obvious extension of this investigation was Dr. Frankland's experiment of placing a lighted spirit lamp in compressed air. "By pushing the condensation sufficently far, the flame may actually be rendered smoky, the sluggish oxygen present being incompetent to effect the complete combustion of the carbon." For, "although by compressing the air we augment the number of active particles in contact with the flame, we, almost in the same degree, diminish their mobility and retard their combustion." It would almost appear as if the human furnace behaved in the same way in condensed air; or otherwise it is difficult to account for the Welsh colliers of the Tynewydd accident living some ten days without food, but in an atmosphere of compressed air.

It results, mainly from this physical fact of the necessity for dilution, that the smaller the jets into which the air for combustion is cut up, aud the greater the velocity with which it is impelled into the solid or gaseous fuel, the less the amount of air required for diluting the gaseous products of combustion. Apart from diluting the gases, there are other incidental advantages. In the first place, any gas generator working with blast is independent of changes in the weather, delivering equable volume of gas; and the same applies to the supply of air for the actual com-

bustion in the combustion chamber. It is also evident that nothing of that mentioned above can occur; the furnace is entirely independent of changes in the wind and weather, the gaseous products and the air always meeting each other in regular quantities. Blast also allows the use of slack with greater facility, as the air can be easily propelled through the layer on the grate. Applied both to the producer and to the supply of air, not merely is the nature of the flame, but also its intensity, made variable at will; and another advantage of directing gas furnaces in which blast is used to generate the gases, is that all the advantages of blast are gained without any chance of the draught driving ash deleterious to the iron over on to the hearth.

On the other hand, with the use of blast under the bars of the producer, there is undoubtedly, *primâ facie*, more difficulty in getting at the grate. At Round Oak, however, we understand that this difficulty is not felt at all, the bars being simply cleaned out at the end of each heat, when the blast has, in anv case, necessarily to be shut off.

CLOCK MAKING.

HOROLOGY is a description of the arts which is based on a knowledge of various machines used in all ages for the measurement of time. Last month's *Practical Magazine* contains an article on watch-making. In this second part it is proper to speak of *Clocks*, omitting the older methods on which all instruments have their foundations, viz. the Sun-dial. Francis Berthond, a continental writer who treated the subject of clock-making more voluminously and efficiently than any other writer, ends his labour by a decision not as yet controverted, that the clock is not the invention of any single individual but a combination of successive inventions by different persons and in many generations. Wheel-work was known in the time of Archimedes. A weight applied as a maintaining power would probably have a fly, like that of a kitchen-jack as regulator. Out of this would come the ratchet-wheel and click for winding it up independently of the great wheel: this would bring out the Balance: and now that the machine had so far grown, necessity would indicate a dial-plate and hand, with its apparatus. All this completed, there would be wanting the striking part and its arrangements.

A similar series marks the uses to which clock-work has been applied. One of the early forms was that of astronomical calculation, then used for ascertaining the longitude at sea. Tycho Brahe, the celebrated astronomer had four: one for hours, one for minutes, one for seconds, and a large one that had but three wheels and was three feet in diameter. Galileo's observations led to the construction of the pendulum clock, and that would bring us down to the time of Richard Harris, the father of English clock-making, of whom mention occures in last number.

But we must do honour to Henry de Wyck, who did more than any single man in effecting combinations, and whose labour indicated the future improvements by induction. His is frequently referred to as "the rude clock." The escapement is the most important part of a clock, and this part was the utmost step of the subsequent changes. His crown wheel escapement has been slightly altered to the following, Fig. 1. Wyck made

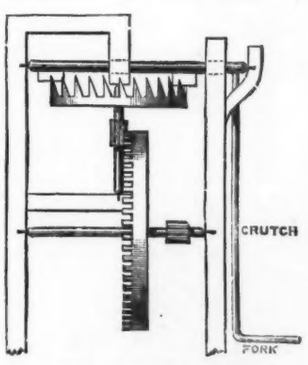


Fig. 1.—CROWN WHEEL ESCAPEMENT.

his weights to be suspended from a bar along the top, and regulated to time by stopping the weights. All the difierence between his escapement and the above being that one of the weights in his balance is now set in a vertical instead of a horizontal plane. The bent end, called fork, connects the pendulum with the "crutch."

The next important addition to the improvements in clocks is the invention of the Anchor escapement, Fig. 2, and this like

Fig. 2.—ANCHOR ESCAPEMENT.

most others that have stood the test of time, belongs to the English. Berthond, in all his jealousy in favour of foreign inventors confesses it to have been the work of Clement of London, in 1680. The great advantage of this escapement over the former is that it allows the escape to take place in a small angle of vibration, thereby preventing the necessity for the maintaining power to act upon the pendulum with so great a force, and by the introduction of a heavy ball leaves that to be done by the uniform power of gravity. This Clement introduced suspending the pendulum by a spring. Hooke claims these inventions, but it is rather as a competitor than a contriver.

Fig. 3.—DEAD BEAT ESCAPEMENT.

Fig. 3 represents Graham's Dead-beat Escapement. The Anchor was a great improvement on all else, but it was imperfect, in that, at every vibration, a recoil took place. The pendulum, a heavy body, vibrated a considerable distance after the tooth had performed its office of impulsion. As soon as that is done, the tooth falls from the pallet, and another pallet falls on another pallet which is moving under the same pendulum in the opposite direction to that in which it will when it receives the impulse from the tooth. This produces a retrograde or backward motion called the recoil. This Fig. 3 is familiar to all, and is the most simple and effective. When it is well made it equals all its subsequent rivals. The grand clock of Benson's in the 1862 Exhibition was so fitted in connection with the Remoinaîr, a French improvement, to be noticed presently. With the escapement and the mercurial pendulum, having a heavy ball moving in a very small arc of vibration, time-keepers are made whose average variation is less than a quarter of a second daily.

The latest and best is said to be that known as the three-legged gravity escapement, Fig. 4, in a front view; the pellets are lifted by the three central pins. The locking teeth vary in size from one to nearly two inches. The horizontal pieces projecting

from the top of the pallets form the adjustment for the arc of the pendulum. This has advantages, first, in not requiring oil ;

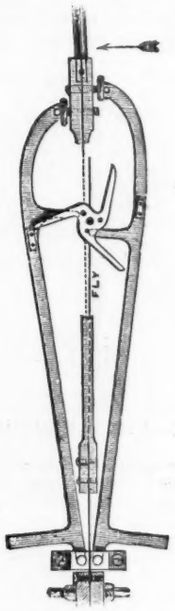


Fig. 4.—THREE LEGGED GRAVITY ESCAPEMENT.

second, has the very smallest friction ; third, no recoil or impelling force ; fourth, unlocks by gravitation ; fifth, more equal in the arc of vibration ; sixth, is less liable to stop in working, etc., etc.

The double three-legged escapement is the like principle applied to turret clocks.

Now we notice the *Remontoires* or gravity escapement in which the impulse is not given to the pendulum, but by a small weight lifted up or a small spring bent up by the clock-train at every beat, those weights can be lifted either faster or slower as may be required. There is also a train remontoire very similar, the chief difference being that the small weight or spring which gives the impulse to the pendulum is not wound up so frequently, say half a minute. Its use is to counteract the various errors to which large clocks driving heavy hands are liable, and it diminishes the friction produced by using heavy weights : such as that just mentioned, illustrated below, figs. 5 and 6, the weights for which amounted to more than two tons. The remontoire is the best regulator.

The Modern Turret Clock combines the highest skill and best experience and may be thus described. Fig. 7. The bed or frame is of cast iron. The barrel on which the cords are bound has a metal cup in front, and a toothed wheel at the back end : between this is a metal tube adapted to the width of the frame. Passing through this drum is an axle or barrel-arbor having on the back end the main or barrel-wheel fitted to allow the weight-carrying line to be wound upon the barrel without moving the wheel which is kept in place by a cap pinned tight on the arbor. Upon the barrel wheels are clicks that fall into the toothed wheel, and springs that keep them in place during the winding up. At each end of the barrel-arbor is a pivot in brass bearings fitted in plumber-block, and bolted on the frame with bolts and washers. Beyond the pivot is a square frame to receive the winder.

The uprights or small frames for carrying the going-train contain an arbor across, having at the back a pinion working in the teeth of the barrel wheel, and at the other end the centre

Fig. 5.—BENSON'S EXHIBITION CLOCK EXTERIOR.

wheel with teeth cut in it; above the wheel is another pinion with a wheel at the other end receiving into it, called the third well and pinion, into which the escape-pinion runs. On this arbor is fitted the escape-wheel having very fine teeth; above the escape-wheel is the verge-arbor to which are fitted the pallet arms. The material is polished hard-steel, at the back

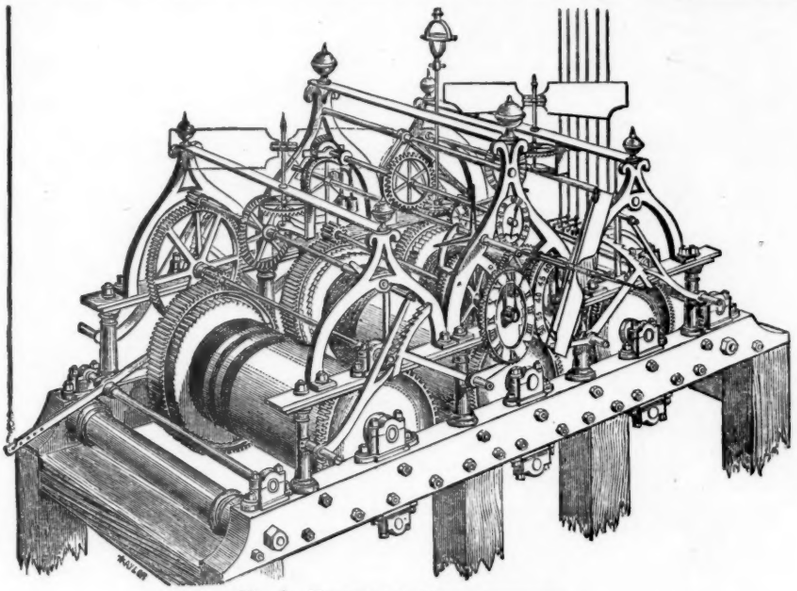


Fig. 6.—EXHIBITION CLOCK INTERIOR

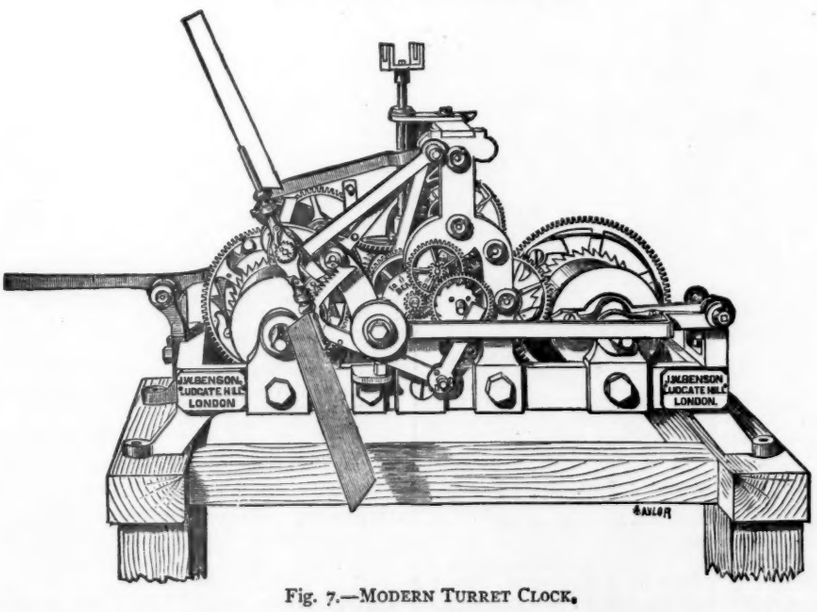


Fig. 7.—MODERN TURRET CLOCK.

end is the crutch connecting the escapement and the pendulum rod. Upon the arbor that sets the hands to time are two springs

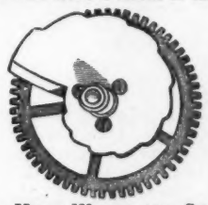


Fig. 8.—HOUR WHEEL AND SNAIL.

to keep in place a wheel fitted loosely on it, and working in the teeth of the centre wheel. The hands are set by a key that fits on the front end of the arbor; at the back end is a joint of iron rod connecting the clock to the dial and working the outside hands. All these arbors are turned with suitable pivots into brass-bearings screwed into the upright and bolted to the frame. On the front upright is fitted an index dial for setting the outside hands, having two wheels. On the largest of these—the hour wheel is fixed a snail Fig, 8, having 12 steps for the hours. The striking-train is a barrel similar to the going-train, but it has a toothed-wheel or camm fitted on the back of the barrel wheel, for raising the hammer that strikes the bell, by means of a lever called the hammer-tail. This train of wheels and pinions consists of,—the pallet pinion fitted tight in the pallet arbor and working in the teeth of the barrel-wheel; at the front end of this arbor is a pallet of steel working in the rack Fig, 9, and gathering it up as the blows of the hammer strike the hours.

Fans are attached to the fly pinion for regulating the striking,

making the intervals shorter or longer. The pendulum rod,

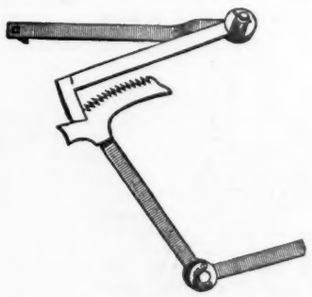


Fig. 9.—THE RACK.

Fig 10. has a brass top and adjusting work on a steel spring, by means of which the clock can be put in beat with great exactness. At the bottom of this rod is an iron screw and nut for raising or lowering the pendulum bob, and thus making the clock go faster or slower. The dial-work for driving the hands are outside at the back of the dial. If the clock has to drive more than one pair of dial hands, bevelled wheels are used, cut to suit any angle, so that it does not matter how far off the dials are, or how many of them, so long as the proper expansion and universal joints are fitted.

Fig. 10.—PENDULUM ROD.

The hammer-work is—an iron frame with arbor pivoted into bearing brass and fitted with a lever, one end of which holds the hammer-head, and the other raising the hammer which is lifted by a wire from the hammer-tail. A steel spring also is attached to the lever to prevent the hammer clattering when it strikes on the bell.

Dials are of any material. Copper has many advantages for plain work. Ornamental dials are often of slate in skeleton frames, or with Minton's or encaustic tiles. Specimens of Mr. Benson's are well known, as at the international building in Cromwell Road and the Synagogue at Ramsgate. Properly a dial for public clocks should never be less in diameter than its height ; and those at St Paul's and Westminster are larger and none too large. The illumination of such clocks have been greatly improved in these last four years by the use of colour and glass ; so that now a clock is best seen at night. Hands are made of copper and ought not to be ornamental. This is an elegant sample of a Memorial Turret clock dial, Fig 11.

The ancients are famous for their wonderful clocks, and we are not without examples, one of which is still in good working order that which decorated the front of old St Dunstan's Church in Fleet Street near the corner of Chancery Lane. Fig. 12. When the church was taken down the old curiosity went off by auction into the hands of the late Marquis of Hertford for

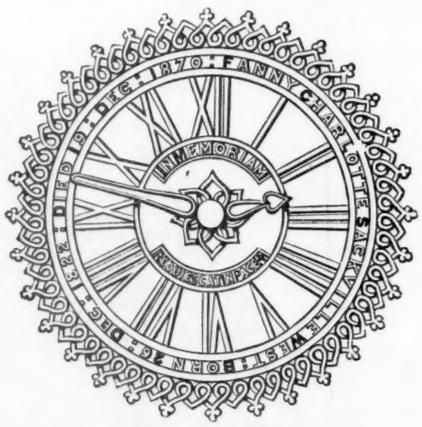


Fig. 11.—MEMORIAL TURRET CLOCK.

whom Burton erected St Dunstan's Villa in Regent's Park, London. There it is with its automaton giants striking the hours and quarters just as it did in old London when located in the City. The other example is that at Wells Cathedral. The works have worn out and are modernized ; the face, Fig, 13, is still there with all its ornament and information.

Fig. 14, represents St James's Palace Clock, one of the most ancient public time-pieces now in use, and which is likely to be removed to South Kensington. It has a locking plate with ting-tang quarter, the quarter hammer being raised from the pin-wheel while the striking hammer is lifted from the pins in the main-wheel. The escapement is a crown-wheel with teeth on the edge, and the pallets work upright instead of over the top like a verge. The whole of the going train is attached to the one bar, so that all the works have to be removed if one piece needs repair or change. The pendulum rod is of iron.

One more curious and public specimen and we end, for if we were to speak of the continental clocks it would occupy too much space. St. Paul's is one of the best example of old fashioned clocks in London. It may be described as a ting-tang quarter on the rack principle having hammer raised from pins in recoil, beating two seconds with a wood rod pendulum. The length of the minute hand is eight feet and its weight 75 lbs. the length of the hour hand is five feet five inches, and its weight 44 lbs. The diameter of the bell made from old " great Tom of Westminster is about 10 ft, its weight 11,474th ; the hammer weighs 145 lbs. and clapper 180 lbs."

The illustrations here given are entirely from the factory of Mr. Benson of Ludgate Hill, whose information and courtesy has been of much value in the preparation of these articles on watch and clock making.

IMPROVEMENTS IN THE MANUFACTURE OF ALCOHOL FROM POTATOES, MAIZE, BEET-ROOT, ETC.

WE extract the following information with respect to certain improvements which have lately been made in the manufacture of alcohol from potatoes, maize, beetroot, molasses, etc., from an exhaustive paper, on the subject contributed by D. Häcker of Halle, to D. Hofmann's *Reports on the Progress of Industrial Chemistry* during the last ten years.

Premising that our readers know that any vegetable matter containing starch, such as the pulp of the potatoes, may have its starch first transformed into sugar, and then into alcohol by the action of malt, the first improvement that calls for our attention is a new method of increasing its percentage of *diastase*, the principle which acts as the ferment. Fleck has discovered that by the treating barley with dilute nitric acid all necessity for the ordinary malting process in which every grain is made to spread by the application of heat and moisture is entirely done away with. As yet, however, this process has

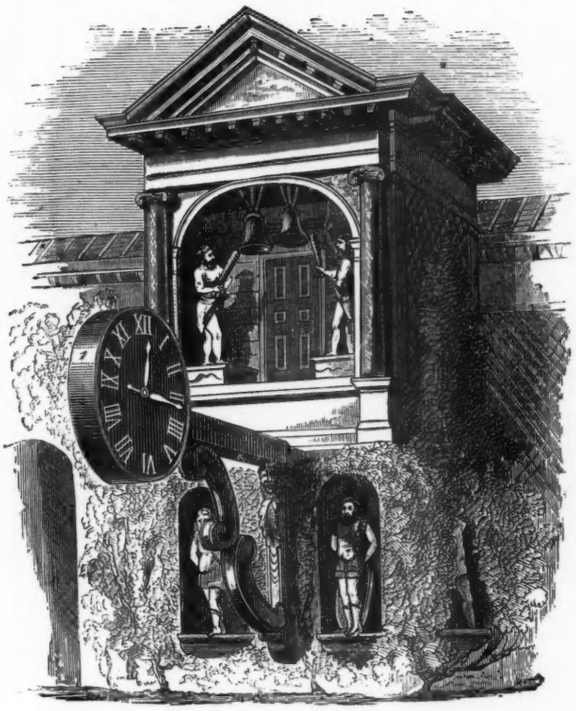


Fig. 12.—St. Dunstan's Clock.

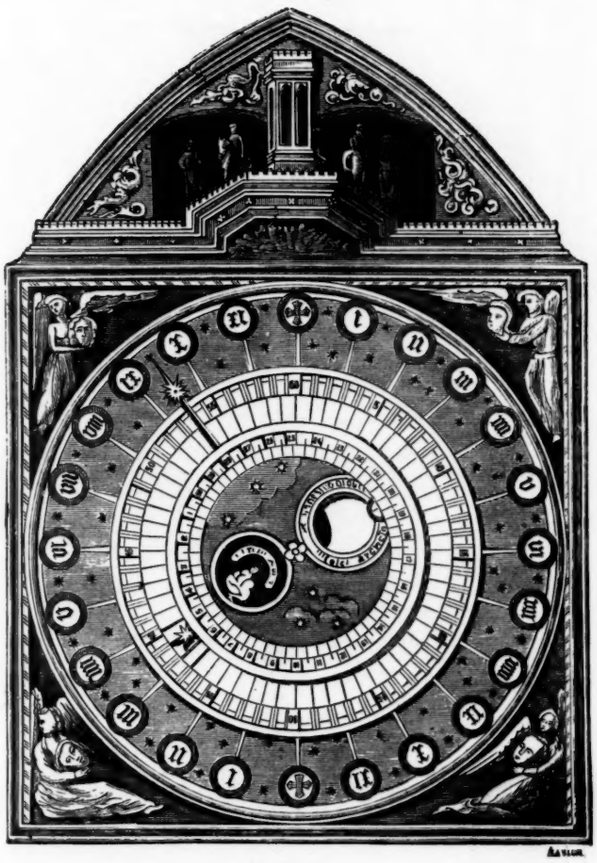


Fig. 13.—Wells Cathedral Clock.

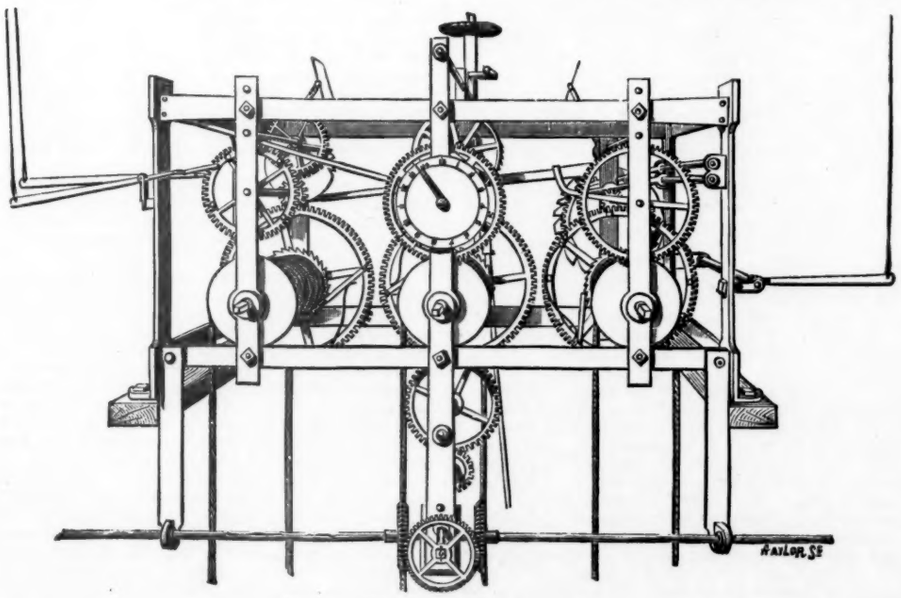


Fig. 14.—St. James's Palace Clock.

not succeeded on a large scale, although perfectly successful in a small one.

Great improvements have been made in the treatment of the potatoes preparatory to saccharification and fermentation. The tubers were formerly exposed in an open boiler to the action of low-pressure steam, crushed between rollers, and saccharified by the addition of malt in an open vat. Three different kinds of apparatus, invented respectively by Hollefreund, Bohm, Henze, and Ellenberger, are now in daily use in different parts of Germany. They are all four dependent for their action in the use of high-pressure steam in conjunction with agitatiors driven at a high rate of speed. None of these are as yet perfect, but they must be looked on as a great step in advance.

Hollefreund's apparatus consists of a cylindrical vessel placed horizontally like a steam boiler, 3 metres in length, and 1·60 metres in diameter. The potatoes are introduced through the man-hole, which is at once screwed down, the boiler being about two-thirds full. Steam jets are then introduced at the bottom, and the temperature is allowed to rise to from 137° to 143° C, giving a pressure of from 2 to 2½ atmospheres. An agitator provided with spiral cutters, and running from end to end, is next set in motion, at first gradually, and then more rapidly, until the potatoes are reduced to mash. The operation lasts about twenty minutes, after which the steam is allowed to escape, the temperature falling to 106° C. This temperature would generally interfere with the action of the malt. The mash is next cooled down to about 65° C, by exhausting the air from the boiler by means of an air-pump provided for the purpose. This operation lasts about fifteen minutes. The valve of a pipe communicating with a vessel containing a thin mash of malt is then opened, and the malt solution rushes into the vacuum. The thin malt mash acts upon the potatoes with great rapidity, reducing the quarter part of the starch to the state of sugar. The saccharified potato mash is then drawn off into the fermenting vats, the rest of the operation resembling the old process. So far Hollefreund's process. We must come to Bohm's apparatus which resembles Hollefreund's externally, the steam, however, instead of being injected at the bottom only, also enters at the sides, so that the potatoes are submitted more fully and easily to its action. After the steam has done its work, the rotating cutters are set in motion, and the whole charge reduced to mash. The refrigerating process is peformed in a peculiar manner. The axis of the agitator is hollow, and a stream of cold water is allowed to flow through it. Fine jets of cold water are also injected into the heated mash. When cool enough, the thin malt mash is allowed to pass into the cylinder and mix with the crushed potatoes. The saccharification being completed the mash is allowed to cool down to fermentation temperature, after which it is drawn off into the fermentation vats. Bohm's apparatus so far differs from Hollefreund's, inasmuch as the potatoe mash remains in the cylinder until it is cool enough for the fermenting vats, whereas, in Hollefreund's process, part of the cooling is effected in the vats themselves. On the other hand, Bohm's apparatus will give one charge less than Hollefreund's per day, owing to the mash remaining longer in the boiler while it is cooling, whereas Hollefreund's is ready for a new charge as soon as the first one has been run into the fermenting vats to cool An extra refrigerator might, it is true, be attached to Bohm's boiler, but the operation could not be conducted so cleanly, and there would be a greater chance of lactic fermentation setting in. Bohm's process requires more action than Hollefreund's ; in the one case, one litre of mash being cooled with ¾ of a litre of water, whereas in the other 2½ are required to produce the same effect. It will be seen, from what has been said, that each of these processes has its merits and demerits. Where there is a plentiful supply of cold water Bohm's would have a slight advantage.

Henze's process is a cheap and simple modification of two others, and is suited to small manufacturers. The apparatus consists of an upright cylinder with a conical bottom. It is so constructed that fresh changes of malt and potato mash flow in alternately, so that very little rise of temperature takes place. The mixture, as it becomes saccharified, flows off into the first fermenting vat. Great care must be taken to prevent the temperature rising during this point of the process, or great loss will be sure to arise. Henze's apparatus, although less complicated and cheaper to work than the other two, is very liable to go out of order unless intelligently and carefully worked.

Let us compare the amount of alcohol produced by the three processes we have described with that given by the old method. It may be as well to remind our readers that the starch grain of the potash is said by some physiologists to consist of a little sack or bladder of amylaceous matter, and by others to be made up of skins or layers of this substance, laid one over the other like the divisions of an onion. Whichever of these opinions we adopt, one thing is certain, that the starch granule must be broken up before the diastase of the malt can effect its transformation into sugar, and that the more effectually this is done the greater will be the yield of sugar, and consequently of alcohol. By the old process a great proportion of the grains of starch escaped intact, and the yield of alcohol was diminished. The malt, too, had a great deal of work to do, not only in saccharifying the mass and converting the sugar into alcohol, but also in breaking down the starch grains during the first part of the operation. Under the new method the time taken by the saccharifying process has been reduced from two or three hours to a half or three quarters of an hour. By the old process a given quantity of potash pulp of good quality gave 5½ per cent. of undisintegrated starch and pulp of a superior quality as much as 12¼ per cent., being a mean of about 8½ or 9 per cent. on the whole. By Hollefreund's process, the general average of the potatoes given in 1872-73, gave 2½ per cent. of undisintegrated starch ; that of 1873-74 3¾ per cent. or a mean of 3⅛ per cent. Bohm's process for the potatoes of 1873-74—a poor year,—gave 3·85 per cent., and Henze's for the same year, 4·48. per cent. The season of 1873-74 being a bad one, it is hardly fair to use the latter figures. Taking, however, 3½ per cent. as an average of both years we find a saving of starch of 5 per cent. Not only this, the pulp being much more liquid the action of the malt in both parts of the process is much more complete and rapid. We now come to the second part of the process, and we here find that a similar saving is effected. The average waste of sugar in the old process was close upon 4 per cent. The following table shows the loss in the case of each process :—

Hollefreund,	1·39 per cent.
Bohm,	1·29 per cent.
Henze,	1·56 per cent.

or an average of 1·40 per cent., or 2·60 per cent. in favour of the new processes, making altogether an economy of nearly 10 per cent. in the yield of alcohol. The new processes, however, have their drawbacks on account of their being very great improvements. To begin with the apparatus itself is more costly, and in order to work it we require a larger amount of fire, which, of course, means increased consumption of coal or other fuel. It is clear, therefore, that a certain amount of the saving is absorbed by interest or capital, and it takes some time before the apparatus begins to pay itself. For small capitalists who can superintend the whole of the operations themselves, we think Henze's invention is the best.

Another apparatus has been introduced by Ellenberger, which promises to supersede all the others, but as yet it has been too short a time at work to say much about its performance with any degree of certainty. It is to some extent a modification. The potatoes fall from a vertical boiler into a refrigerating vessel, where they are subjected to the action of a kind of rasp or grater, which transforms them into a very finely divided mash. This same rasp or grater also cuts in the same way as the malt mash, so a notable saving in the latter is effected. In the case of waxy, or slightly decomposed potatoes, the cutters used in the first three processes do not always sufficiently disintegrate the tubers, so that in the case of potatoes, if bad or medium quality, a large portion of the starch must necessarily escape saccharification. Ellenberger's apparatus seems to be coming into great favour, but owing to its recent introduction there are but few data to go upon by which we could judge its merits.

In one respect, it is superior to its predecessors ; it is specially adapted for manufacturers who use maize in conjunction with potatoes. The cutters so often spoken of would be useless in disintegrating maize, owing to the large quantity of oil contained in that grain.

Maize alcohol has been made in Hungary for many years past, and is in fact a staple product of the maize-growing districts. The maize is generally mixed with potatoes in the proportion of one part of maize starch, and two parts of potatoe starch, the amount of starch contained in the samples having been previously roughly estimated. It is, however, during the summer when the potatoes are at their full perfection that the best maize and potatoe alcohol is made. It always has a bad taste and odour, and can only be used in manufactures where offensive odour is of no great consequence. In Italy there are also extensive maize alcohol distilleries.

There are certain inherent difficulties in distilling alcohol from maize which require much ingenuity and attention to get over. Maize contains large quantities of fatty and oily matter which, so to speak, wraps up the starch grains in a greasy envelope which is only penetrated by the diastase of the malt very slowly. There is also great difficulty with reducing the grains to the necessary firmness ; for this purpose Ellenberger's apparatus is particularly well adapted. In Hungary the saccharification of the maize is aided by acting on the mash with sulphurous acid gas. This is effected by adding to it a certain proportion of sulphite of sodium.

A dilute solution of sulphuric is then thrown in, which, acting on the sodium salt, liberates the sulphurous acid gas. In Italy another method is adopted. A solution of sulphuric acid is added to the maize mash, and the mixture subjected to a pressure of two or three atmospheres. When the saccharification is complete milk of lime is added to neutralize this sulphuric acid, and the mash is cooled and fermented. By this means the yield of alcohol is notably increased.

Beet-root alcohol must next claim our attention. But little of this kind of alcohol is made in Prussia and the German States generally, owing to certain fiscal obstacles which distillers have vainly tried to have removed. The Prussian Inland Revenue exacts its spirit dues not on the distilled spirit but on the wort, the volume of the wort being measured, no notice being taken of its richness in saccharine. Hence potatoes giving a much richer wort bulk for bulk than beet-root, the distiller naturally prefers the former. In South Germany the case is different, but even there the beet-root spirit manufacture is not in a flourishing condition.

In Austria, when a similar system was in vogue, the method of levying the spirit duties was changed in order to encourage this branch of industry. Beet-root spirit distilleries sprung up in all directions, and a thorough revival of the trade was expected; but the newly built establishments were speedily transformed into potatoe or maize spirit distilleries, or else closed. On the other hand, in France the manufacture is spreading daily.

The latest improvements in beet-root distillation are those of L. Siemens and Champonnois. In Siemen's process the beet roots are cut in slices in a suitable machine and heated in a vat in water to which a certain proportion of sulphuric acid has been added to a temperature of 85° C.; this operation is performed in a flat bottomed vat. The mash, when sufficiently saccharified, is transported to the fermenting refrigerators. The yield of alcohol is about 5 per cent. of the weight of the beet-roots.

In Champonnios's process the sliced and acidified beet-root is left in contact with the heated liquor for an hour, no vat being used, after which it is siphoned off into the fermenting vats.

The molasses left during the process of refining beet-root sugar contains from 40 to 50 per cent. of fermentable sugar. The spirit distilled from beetroot molasses has, however, a worse odour and flavour even than maize or potatoe alcohol. The treacle is generally fermented with malt made from rye which does not diminish its abominable taste and smell. The treacle being strongly alkaline, from lime and potash, has first to be neutralized before it is subjected to the action of the rye malt. It is thus exposed to a heat of from 20 to 25° and the alcohol distilled off. The residues are generally burnt for the sake of the potash they contain, although the fall in the price of this alkali through the discovery of the potash mines at Stanifirth has greatly diminished the distiller's profit in this direction. They are of no use for cattle food except they are mixed with a fair proportion of potatoe spirit residues.

Having described the improvements made in the first two processes of alcohol manufacture, we now come to the newest apparatus for distilling off the spirit from the fermented mash or wort. As before explained, on account of certain fiscal restrictions which exist in Prussia and other parts of Germany, it is to the interest of the distiller to make his wort as thick and as rich as possible, knowing well, that whether it is thick or thin, strong or weak, he will pay just the same tax upon it. Under other circumstances, a hictolitre of wort would contain from 35 to 40 kilogrammes of solid matter, whereas, in Prussia, the same quantity of liquid contains nearly 85 kilogrammes. The use of such thick mash requires better machinery of every kind as well as a greater consumption of fuel; although weight for weight, the yield of alcohol is much less than when thinner mashes are used. The crushing of the potaoes must also be more completely carried out. The apparatus for grinding the malt must also be more powerful and more rapidly worked. Then again in former times distillers cooled the fermented wort by letting it flow into shallow vats, and agitating it with dashers worked by hand. This mode of cooling would, of course, be impossible with a thick mash. Great improvements have been made in this part of the process, but much still remains to be done. Large shallow coppers were first introduced. The hot saccharine mash was agitated by means of revolving dashers, an amount of cold air being drawn over its surface. Wrought pans have, however, almost entirely superseded them.

C. Siemens's refrigerator consists of a rectangular wrought-iron tank, into which the mash flows over a gently inclined plane, a strong current of cold air being sent in an opposite direction. In very hot weather this current of air is passed over layers of ice.

L. Siemens's refrigerator is known as the exhauster. It consists of a vertical tube divided into horizontal compartments, which communicate with each other. In the centre of each compartment is a horizontal disc, which revolves at the rate of 600 or 800 times per minute. The hot mash is allowed to flow in at the top of the cylinder, and, falling in the revolving disc, becomes immediately pulverised, and thrown against the sides of the compartment, when it becomes condensed once more, and falls into the next compartment, where it is again subjected to the becoming again condensed and falling into the third action of a revolving disc compartment, and so on to the bottom. During its journey from the top of the cylinder to the bottom it is subjected to a strong current of cold air. Some distillers object to this apparatus on the ground that it is difficult to reduce the mash to a temperature of less than from 25° to 28° C, which is too high for fermentation. Others again say that it transforms the mash into a scum, which is acted on by the malt with great difficulty.

Liebeg's system of refrigerators, which consist of vertical or horizontal triple tubes, the cold water passing through the outer and inner tubes and the mash between, have been improved greatly by Nägoli and others. These refrigerators may be used with great profit where the supply of cold water is plentiful and constant. The hot mash passes upwards, and the cold water passes downwards. From 1½ to 2 litres of cold water are necessary to cool 1 litre of hot wort.

The continuous still seems to have come into general use within the last few years in most large distilleries. It was first invented by Savalle, a French engineer, and has since been greatly improved by Nöhring, Krause, Römer, and others. It consists of a vertical cylinder, divided into compartments by a series of horizontal discs. Steam is let in at the bottom, and the wort at the top. The wort flows gradually downwards, and being constantly met by the hot steam the vapour of the alcohol is conveyed away with the latter, and passes out of the top of the still into the refrigerator, the exhausted wort flowing out at the bottom. By the wort passing over so many discs every particle of it comes in contact with the hot steam.

C. Siemens's apparatus resembles L. Siemens's refrigerator in its construction. The wort falls on the revolving discs, becoming converted into a cloud, and the hot steam passes through it.

Refrigerators for condensing the distilled alcohol have also received great attention. They mostly consist of three tubes, one inside the other, the hot vapour passes down the middle tube, while cold water passes up the inner and outer ones.

There is also a system in which a series of lenticular basins are used instead of tubes, the principle being the same, but the surface greater.

Great pressure having lately been brought to bear on the German government in relation to the incidence of the spirit tax, a proposal has been made to levy directly on the spirit according to its alcoholic strength, instead of on the wort, according to its bulk as at present. In anticipation, a number of alcoholometres have been contrived for showing continuously the exact amount of absolute alcohol contained in each litre of the distillate as it flows out of the refrigerator, but none of them appears to be sufficiently accurate.

Various experiments have been made during the last few years to obtain alcohol in paying quantities from such materials as straw, wood, madder refuse, and rein deer moss, but without success. Certain experiments made in Norway and Sweden, where the last named material is very abundant, point to possibly favourable results, but for the present we must be content to draw our supplies of alcohol from substances like potatoes and grain, which contain notable quantities of starch in a saccharifiable condition.

Inventors should rather devote their attention to improving processes which have stood the test of time, than to devising new schemes which must be necessarily more or less utopian in their character.

MODERN MECHANICAL PROGRESS.

WHAT an extensive catalogue might be made of ingenious contrivances which have gone far towards becoming sources of profit, but have failed at the last minute. Indeed, there is reason to fear that a great number of those waifs and strays are searched out and brought forward as inventions by living men, who have adroitly ransacked the relics of past days. During the past four months there have been produced a considerable number of little contrivances of this kind; they would not remunerate a capitalist now, but ultimately they will, as the tastes of the people change. Here are a few:—*Match Boxes.*—One of the

longer sides is rounded and slit from end to end, and the sides are made to spring slightly so that a match (caught with a finger and thumb at a notch) can be pulled out through the slit. *Staining Paper.*—The web of paper is subjected on one or both occasions to the action of liquid staining matter (in a trough or supplied to a roller); then to heat, to evaporate and fix. *Writing Pens.*—A metallic spoon-shaped reservoir, containing *e.g.*, aniline, is connected with the pen by a flexible stem. Again, pens are coated with a soluble material having aniline for its base, and in use the pen has merely to be dipped in water. Then of those actually protected, how interesting it is to observe the continued attention to the supply of domestic mechanical novelties which augment the charms of home. Mr. Fenby improves folding stools, chairs, &c., in a contrivance wherein the framing of the stool consists of four pairs of bars, the bars of each pair crossing each other at the middle of their lengths, and jointed there by a pin; the tops and bottoms of each pair are connected respectively with those of adjacent pairs by means of metallic angle caps, so that all the bars are connected together. Modifications are introduced for camp chairs, tables, and beds. Mr. Imray simplifies the locks for trunk-cases, in which the staple plate and key-hole plate, when shut, are flush with the case. The latter plate is locked by a snap provided with a stud fitting into an opening in the lockcase. Both plates have a spring inside so as to spring open whenever released. To open the lock the snap stud is pressed to force the snap to liberate the key-hole plate; and on unlocking the lock with the key the hinged staple plate flies open. To shut, the staple plate, and then the key-hole plate, are merely pushed into their respective recesses. And Messrs. Baitton and Albright, Wire Dish and Plate Covers, have an invention which consists in fastening the parts connected to the wire gauze with rivets instead of solder, and strengthening the connection by corrugation of the gauze and the metal forming the centre-pieces and the rims.

Domestic waste is one of the household sins which every master of the house should resolutely oppose. One may see in London waggon-loads of cinders, that are of more value than any coke, thrown aside daily by improvident and useless servants. Every contrivance for preventing such waste tends to inculcate a just economy by exciting a pleasure in the result of mechanical operations. Mr. Lake's invention for cinder sifting consists of a cylindrical case with a conical chamber on its axis, having a wire gauze base; this chamber can be rotated by means of a handle exterior to the cylinder (protected by a rim.) Near the middle of the case is an annular diaphragm, one part of which is hinged to open towards the mouth of the case. Cinders are poured into the conical chamber through a conical guide; a lid is put on the sifter, the cylinder is then turned on its side, and the handle is rotated; thus the ash and fine particles pass through the wire gauze. By inverting the case after removing the lid the sifted cinders are emptied from the conical chamber and the ash passes into the upper half of the case, whence it cannot return; it is afterwards removed by a door near the margin of the case.

Here is another on a most essential element of domestic arrangement, patented by Mr. Bell, for Fixing Lock and Door Handles,—a source of annoyance most provoking to every householder that has not built his own house, and to many who have. He says,—In one arrangement, the end of the spindle has a slot through it to receive a pin after having been passed into the knob; in the outside face of the knob a cavity is sunk for access to the spindle end when inserted; this cavity can be closed by a screw piece after inserting the pin. This pin has a loose ring in its head to prevent its passing entirely through the hole. Again, the neck of a knob is slotted correspondingly with the spindle, and a pin inserted. An india-rubber collar (on the neck) with corresponding hole for passage of the pin, is then moved round to cover the pin. And one more addition to the multitude that no man can number of chimney-pot contrivances and the construction of chimneys, is made by Mr. Haddan, wherein the pots are formed of two distinct tubes, an inner and an outer, the latter not entirely covering the former, but a space being left below for entrance of air. The inner tube may be surrounded externally with a helical band, and may have within a helical plate fixed on a spindle capable of rotation.

Turning from domestic to constructive arrangements, we must not neglect to observe the attention which inventors are bestowing on the various adaptations of the modern use of concrete in house-building. Villas worth £100 and £150 a year are made of the burnt clay taken from the plot on which they stand and are built in a few weeks as dry as if they had received a year's seasoning: and the idea is good enough to invite further invention, to give ornament and face to what at first was rough and rude. In spite of what orators may say of the construction of dwellings being hypocritical in many ways—namely, by the use of stucco or bad bricks, and the like—there can be little complaint of an invention that takes up the fruitless clay, puts it into the fire, takes the fruitless chalk, puts that into the fire, and, by combining the two fruitless elements, erects an elegant home for man. Surely that is not to be designated hypocrisy! A man must be hyper-critical to assert anything of the kind. Well, in this matter we are favoured with Mr. Sellar's suggestions as an advance in Concrete Building Blocks in a specification of his idea. It is said this relates to compound concrete blocks having a body of coarse material, and a facing of finer and more resistant quality. The latter material is first rammed into spaces between the perpendicular sides of the mould and perforated division plates; these plates are then removed and the coarser material filled in. The interior surfaces of the facing are coated with cement, to prevent penetration of water; which cement may be washed with sulphate of zinc, photo-sulphate of iron, alum, glue, or other solution, when lime is used to form the filling in, to give adhesion.

In fraud-detection there have been many attempts to be perfect, and it is not done. We doubt if it ever can be. Still, every precaution that can aid in the culture of honour and honesty, even by catching a thief, is welcome. Here is one concerning omnibus conductors, tramway collectors, and the like—a source of frightful loss to shareholders, and of profit for thieves—patented by a Mr. Sturgeon. The entrance is commanded by two arms which work in separate vertical planes, the distance between them admitting only one person at a time. The arms are connected, so that when one is made to close the passage the other opens. A weighted tread plate between, when pressed, throws the indicator into gear with the arms. One indicator counts the entrances, the other the exits. The indicators are arranged to stamp the results on cards pressed into a slit in their cases (as at railway booking-offices for dates), and at each point where the fares alter is stationed a person who thus gets the number of exits and entrances stamped on tickets. Again, turnstiles are made with only two arms (at right angles) which can slide through the spindle, or be turned over. Again, a person entering encounters a semicircular arm, which he has to slide round behind him; it blocks the passage in either position, &c.

Mr. Lundh has a contrivance for preventing the escape of sparks from chimneys, which he thus describes:—Round the top of the chimney is fitted a basin, into which water from the boiler is conducted through a tube bending downwards; a tube on the other side keeps the water from rising beyond a certain level. The sparks coming up through the chimney are driven against an inverted adjustable basin over its mouth, and whirled round in the rising steam from the lower basin, till extinguished.

Another on the important subject of steam cooking is from M. Nawrocki. Simpler methods will doubtless be discovered, but every step in the improvement of cookery by the use of steam is so much gain to the country. By his contrivance the food is subjected first to action of steam from quietly boiling water, then to that from violently boiling water, or water itself. The apparatus consists of a metal casing (for water) with central tube, in which a second tube (for fuel) widening out below is placed eccentrically, leaving a space which forms a flue to the fire grate below. Round the lower part of the inner tube system is a small annular chamber in which the water comes into immediate contact with the fire-box. A tube reaches up from it above the water surface in the casing, and bending over, discharges its steam into a descending tube, which can be connected to the cooking receptacle. The head of the descending tube is first turned round a little to receive the less heated steam from the outer chamber.

In Bedroom Furniture Mr. J. H. Johnson has a complete and compact apparatus, which consists in filling up, in any bedstead, the space below the level of the bed with drawers; also a chamber closet opening on the side of the bed; also a compartment for basin, ewer, &c. Above the drawers shelves may be arranged to be drawn out on supports and serve as tables.

For the better lighting of Cellars from the pavement, Mr. Nairne, adopting translucent glass, has changed the form and grating. The gratings are fitted with glass blocks formed with angular flat-sided ridges on their undersides. In some cases all the ridges are made of graduated sizes, the smaller one being nearer the side to which it is wished to divert the light.

Mr. Lockwood invents a novel method of treating Beer, Ale, &c., for which he has acquired a patent. It consists in distilling off most of the alcohol in the beer, then steeping the hops in this alcohol, and returning it to the beer.

Heating Irons by Gas is effected by the skill of Mr. Parks, in constructing an apparatus that consists of a body-casting with shallow core allowing a short interval between the burner and the bottom of the iron, and a top plate secured by screws; the two parts being held apart slightly by washers, to give exit to

products of combustion. The burner is a flat perforated piece of cast iron attached under the cover by screws; it is slightly hollowed on the upper side, affording a shallow chamber for the mixed gas and air conveyed either through one of the handle supports or through a separate pipe fitted to the cover.

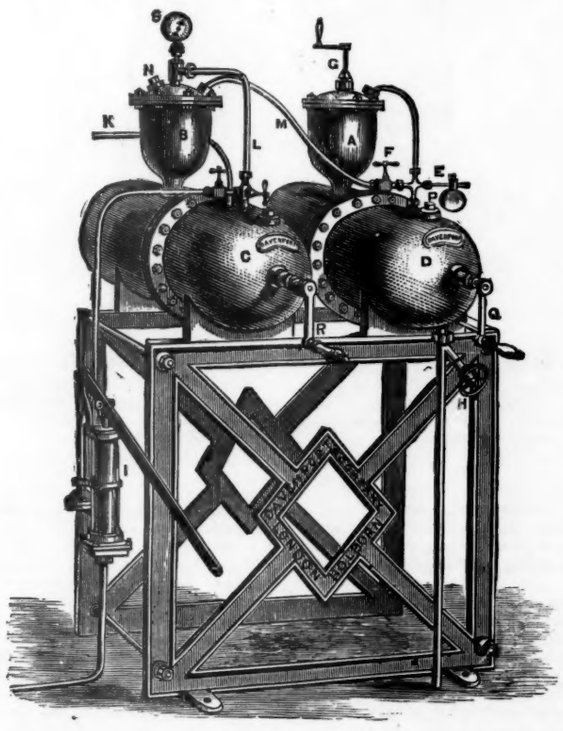
In the Manufacture of Sugar there has been put forth by Mr. Bonnefield a method of extracting and treating juice from sugar-canes, &c., in which the sugar-cane is disintegrated by being presented in bundles to a series of parallel saws in a frame. The frame of cutters is out of contact with the bundle while being raised, but in the descent is brought into contact and caused to cut through it. Each saw blade is made thicker on the teeth side, so that the slides may pass freely between the blades. Afterwards the slices and granules are ground to pulp, then the juice is separated by pressure between rollers. It is then delivered to a metallic vessel lined with woven fabric, and there heated and limed. Then the lining is raised, and takes with it all the foreign matters (to apparatus for washing the same). The juice is again limed, boiled, and allowed to settle. It is drawn off through a thick and close fabric.

THE MANUFACTURE OF AERATED WATERS, &c.

WHEN Cheltenham had a higher renown for its natural mineral waters than it now possesses, the same dislike that many have now to all such drinks existed, although not expressed, in spite of fashion. Every one who at that time went "out of town" in the season, usually visited what came to be called watering-places, but at the beginning of this century many desired that these waters should be made more pleasant to the taste, and Thompson proposed in 1807 to impregnate the Cheltenham and other mineral waters with gases, and to add other substances in combination with those waters. This was followed in 1809 by W. F. Hamilton's "New Mode of Preparing Soda and other Mineral Waters." The original invention of effervescing waters does not appear to have had the ordinary legal protection, but from the above date there have been hundreds of most ingenious contrivances that have remunerated the inventor, and benefited the public, and some of these we will refer to, leaving the "various solutions of alkalies, salts, &c., and combinations of ardent spirits, vegetable acids, aromatic oils, sugars, milk, mucilage, &c., for saturation and supersaturation with carbonic acid;" the "gas obtained by decomposing whiting with sulphuric acid," and most of the sundry ingredients as not within the range of this paper. The chief articles we have to do with are carbonic and tartaric acids, and the method of compression adopted from time to time; and the machinery by which this work is accomplished.

Before describing the especial machines we have illustrated, it will be useful to offer a few of the notable inventions in the terms given by their inventors.

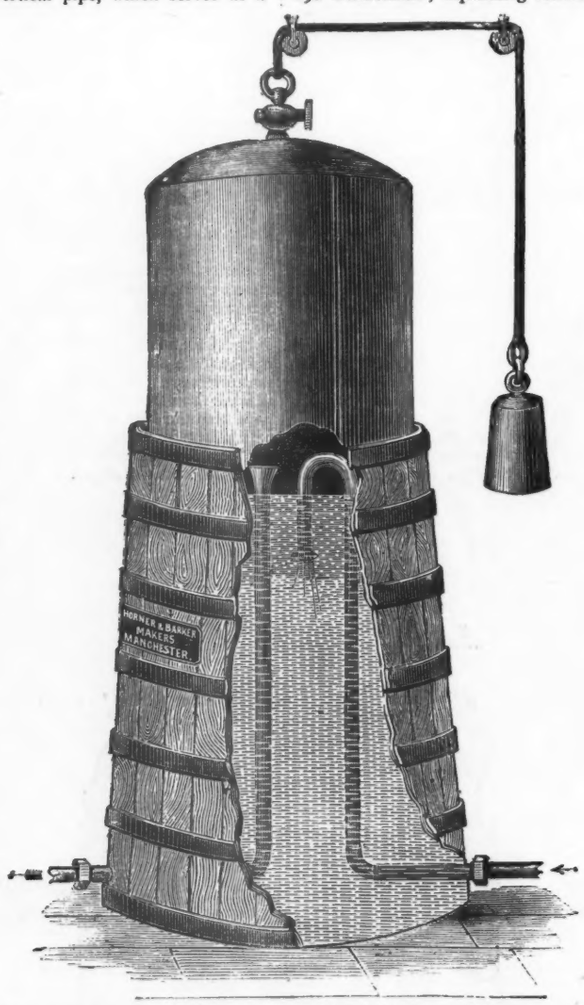
Benjamin Fleet, a celebrated soda water manufacturer, describes his improvement as consisting of a method of combining in one machine the manufacturing apparatus, which he drives with a steam-engine. This is effected "by disposing a steam cylinder on the bed plate of the machine, or other supporting part, and mounting a crank on the end of the machine shaft, to which the piston rod may be directly connected." A suitable feed is applied to supply the boiler. A toothed wheel on the main shaft drives the agitator of the receiver. The gas is economised, and its escape at the safety-valve is prevented by placing the valve on a separate vessel, which is connected by a tube with the bottom of the receiver; this vessel is always filled with water, and when any excess of pressure takes place, "water escapes from the safety-valve," and relieves the pressure, with little or no escape of gas.



Messrs. Davenport have a "Universal Soda Water Machine" intended for confectioners, chemists, hotel-keepers, and others, for making their own aerated and mineral waters, with little labour and cost. They are so adapted that they supply a counter draught apparatus as well as a bottling machine, and simultaneously with the adoption of a syphon filter syphons can be filled. These are being used in private families, especially in India and the Colonies.

An elaborate apparatus was introduced in 1864 by G. H. Ozouf, for the manufacture and utilization of carbonic acid, and apparatus connected therewith. His special claims are, the production of pure carbonic acid by separating it from other gaseous products proceeding from the combustion of coke, charcoal, anthracite, and other materials, and from the burning of lime; the employment of pure carbonic acid in the preparation of soda, seltzer, and other waters.

His apparatus may be varied according to circumstances, as far as regards form and arrangement of parts, and in the number of pumps, reservoirs, saturators, but the general description says it is composed of—a suitable furnace ; a washer containing running water ; an air-pump ; a receiving cylinder ; a number of saturating cylinders partially filled with a solution of sub-carbonate of potash, placed horizontally, furnished with agitators, and communicating by means of pipes of an S-shape ; the last cylinder is provided with a vertical pipe, which serves as a chimney to throw into the atmosphere other gases ; a wooden reservoir which receives the solution issuing from the last saturating cylinder ; two pump barrels mounted the same column and working alternately, the one draws and forces the solution of bi-carbonate into the separating vessels, the other serves to draw off from the separating vessel the solution injected by the first pump barrel, and become basic again ; distilling and refrigerating vessels ; coils for containing steam at 296° Fahrenheit ; separating vessels ; and, lastly, a gasometer.



This illustration represents the gasometer and explains itself. Great care is necessary in its manufacture to combine strength and durability. The bell is made of stout copper, with blow-off cock and ring, and is enclosed in strong well-coopered tub, with internal pipes, &c.

MM. André and Guillot constructed in 1861 apparatus composed of three separate vessels mounted on a frame which rests on a stand. The upper one contains the liquid to be aerated ; the others are in a line with each other, the one is a generator, and the other the purifier. The upper communicates with the top of the purifier by means of a bent pipe ; it is provided at the top with a valve or cock for filling or discharging ; inside there is an agitator, which is rotated by a winch handle ; and near the top is a self-acting safety-valve. Each of the other vessels is fitted at the lower-end with a stopper held in position by a screw pressing on it ; at the top of the generator is a screw collar for the reception of a funnel or filter, and a stop-cock closes the bottom of the funnel after the introduction of the powders, &c. ; the gas generated passes through a pipe leading to the bottom of the purifier ; and at the top of the purifier is a suitable mount for connecting the bent pipe to it. The safety valve has other applications.

About six weeks after this came out, MM. Mondollor invented an apparatus for manufacturing and bottling. The gas generater has two vessels separate. The tube of a pressure gauge is soldered on to the metal mount of the lower vessel, and the mount of the upper one is fixed with a stop-cock which allows the carbonate of soda to descend into the lower vessel, where the gas is to be generated. The mount of the lower vessel is fitted with a nozzle for the attachment of a flexible tube, which connects the generator to the vessel containing the liquid to be aerated ; this tube is provided with a stop-cock. This vessel (saturator) is suspended at its middle on trunnions, so that it can be readily oscillated ; it has two openings, one to which the flexible tube is secured, forms the inlet for the gas ; the other, at the bottom of the vessel, serves the twofold purpose of admitting the liquid to be aerated, and of discharging the same when saturated. The inlet tube is connected inside the vessel to a pipe which descends nearly to the bottom, and has fitted to its lower end a small chamber perforated on its upper surface for the purpose of dividing the gas as it enters the liquid into a number of fine jets. The discharge tube leads to the bottling apparatus.

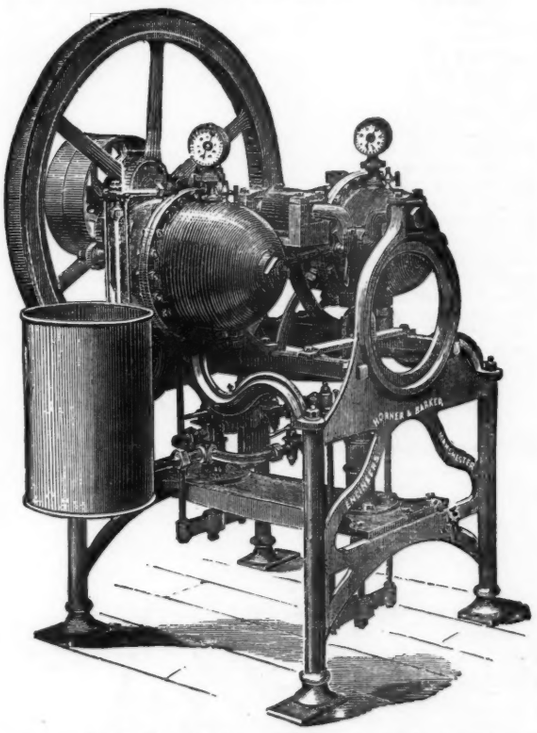
The inventions made of glass, called respectively gasogene

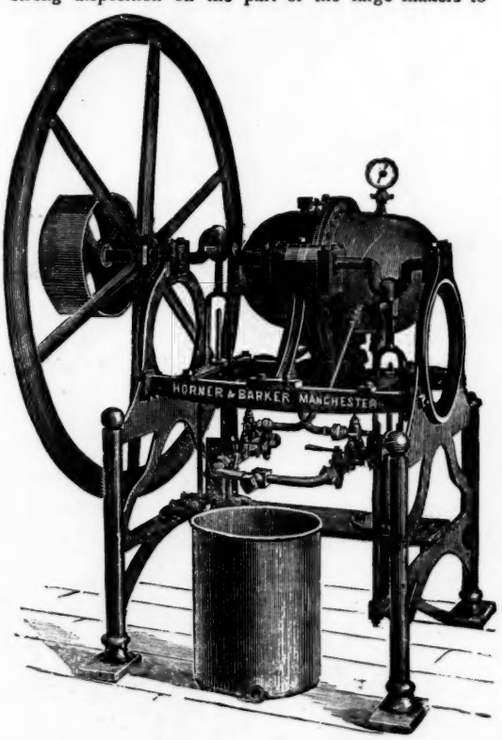
or seltzogene, are numerous. The first is that of Mr. Masters, and is of the well-known hour-glass shape, with a ball at the top; the cheapest of all the contrivances. It had a rival very speedily in that of F. Mathien, whose apparatus consists of an upper vessel to be filled with a liquid, a lower to hold the powders and other ingredients, and a tube which enters both vessels. The neck of the lower vessel, which is fitted with a drawing-off cock, is screwed on to the neck of the upper vessel. The part of the tube which passes through the necks and into the lower vessel is surrounded by a tube, which has on its top a perforated silver disc, and at its lower end a perforated chamber screwed in to it.

To use it, the vessels are unscrewed; the upper one filled with liquid, and into the lower the powders, &c., are placed. The air-tube is then fitted into the neck of the lower vessel, and that vessel is then reversed and screwed to the neck of the upper one; the apparatus is then held "obliquely for a moment," and then placed in its proper position with the upper vessel uppermost; or a stopper may be used composed of two tubes (the upper one carrying the packing, and the lower one attached thereto by a screw), the two valve spindles, one at each end of the stopper, and two cross pieces as guides and stops to them; the valves act independently of each other.

Every student of practical science will have seen in these notes sufficient to give him acquaintance with the general principles of such machinery as is under our observation. We date from 1807; but Gosse, a Genevan chemist, manufactured mineral waters in imitation of the natural, some ten years before; and Jean Paul caught the idea and established a factory in Paris as soon as he could after that. He succeeded in imitating all the famous medicinal springs of his time. Fashion took the course of pursuing mineral and medicinal waters, and Jean Paul made the imitations more agreeable than that of nature, adding thereto the pleasure of "stopping at home."

Our observations must be contrastive as to the machinery employed in this particular production. The English have from 1807 to the present time worked on one principle—improving as they went, it is true, but without varying in the least from the starting point, so far as the chief ruling idea is concerned. Our great manufacturers have held to it, although at the Exhibition in 1861 a better one stood before them. Whether a dread of "Every man being his own soda-water maker," or an inability to understand that improvement is within the law of knowledge, it is unnecessary to inquire. Smaller men have known better, and find their account in the change; and at the present time there is a strong disposition on the part of the large makers to





re-examine their conclusions. When barrels of soda water can be sent five hundred miles and placed under a counter-tap for sale in any quantity, the heavy bottling trade looks about. There is danger in a monopoly, which danger is innocuous if those who have interest in the manufacture will but keep pace with the times in which they live, and the artificial wants that are the characteristics of every age and generation.

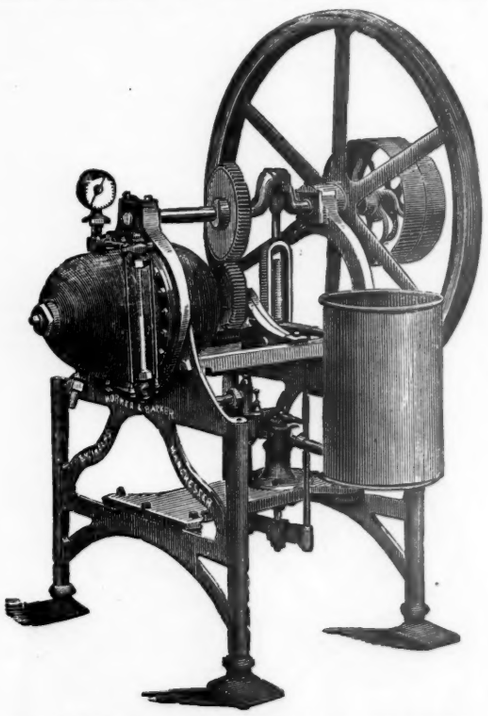
The English system is on one barrel—the American on two. We will describe and illustrate both from the best collection of such machines that has come under our observation.

This is one of the best English system machines; but before its description let us make clear the principle; and this is the key. It possesses two cylinders which can be used together or singly, and at the same time made to supply the same or two different beverages. The process generally in use in England is to generate the carbonic acid gas in a lead vessel, from which it is conducted to a receiver or gasometer, where it usually passes through water, and rises in the bell or top. From this gasometer the gas is pumped with water into a comparatively small stationary cylinder, where it is agitated together until sufficient pressure is obtained, when it is bottled. This is done in various ways.

We illustrate another Double Direct-Acting Soda Water Machine that has but one cylinder made of gun metal, in other respects the principle of both is the same: it has a double cranked shaft and clutch-box to connect or disconnect them, and thus one or both pumps are permitted to work.

A more minute description may be acceptable. The fly wheel when put on the end of the crank will go nearly home. Leather washers must be on all the joints before they are screwed up. The leaden gas generator is placed on a stage sufficiently high to get a pail under and empty it when exhausted. The bell is then lifted out of the tub, and the tub filled with water to about two-thirds of its contents. The pipe that conducts the gas into the gasometer will then dip about four inches in the water; and that which carries the gas to the soda-water machine will be above the water line about two inches, for water must not enter that pipe. As the water evaporates the tub is filled up. The copper bell is lifted into its place, and steadied by cords and pulleys; while the cock is opened at the top the bell descends, but it should not touch the bottom. The cock is then shut, and the gas made as follows:—Unscrew the top cap of the leaden generator, and put in with an iron funnel about twenty pounds of whiting or chalk, well pounded,

and pour in eight gallons of water. The cap is then screwed a little, the whiting and water well mixed until the consistency of



cream is attained. The sulphuric acid is next added by the leaden funnel, and the handle of the generator turned, thereby carbonic acid gas is formed, which will rush out of the top cap of the generator. The cap has been left loose on purpose that this *first* atmospheric air may be discharged. In ten or fifteen seconds the screw is tightened, and the pressure causes the bell to rise; the gas will flow through the pipe into the water, where its impurities are washed out. When the bell has risen about two-thirds up, the cock at the top of the gasometer is opened to let it descend a little in order to get rid of the foul air in the upper part of the bell. The cork is then closed, and must not be re-opened until the water is changed.

Care must be exercised in putting the acid into the whiting lest gas be too quickly generated, and force the whiting to the injury of the machine. When acid does not produce gas, the whiting is exhausted, and should be replaced by taking off the top cap and then removed it by a pail. It is necessary to keep oiled every day, the three bearings of the crank, the guide bob, and the pin on which the sling vibrates; but the plunger must not be greased. Getting rid of the atmosphere, and agitating for a long time under great pressure, are the main points in making fine quality, highly charged, mineral water; by this means the gas is retained, combination perfected, and when poured into a glass it remains bright and sparkling.

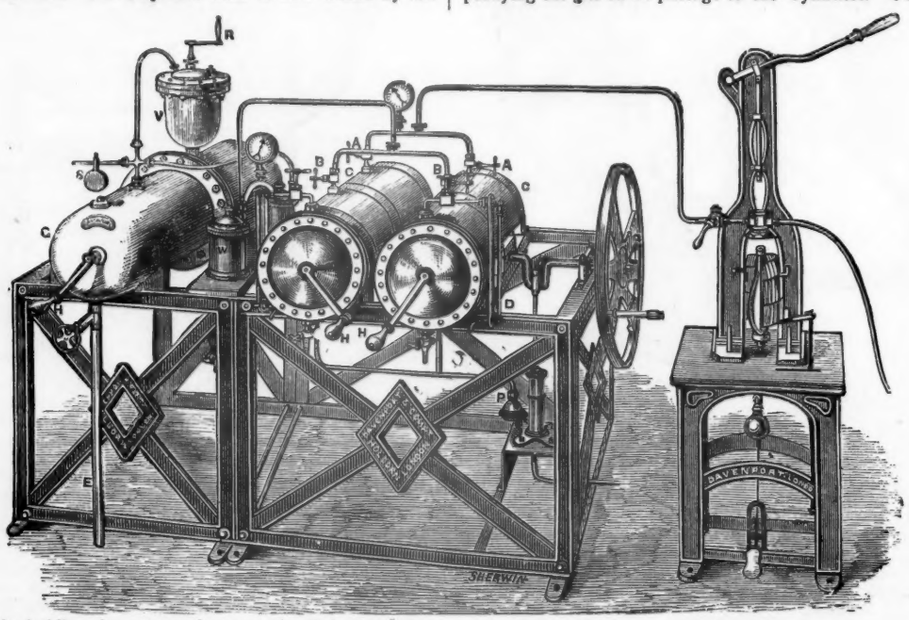
These are conditions that demand attention, and these it is well that the artificer should study.

The Single Direct-Acting Machine has the merit of being large and very strong. The pumps, cylinders, and other appurtenances are the same. Such is the gasometer, solution pan, pipes, and connections. It is a little less costly than the others and gives great satisfaction in the working.

Let us now contrast the American principle: the machinery of which is as follows:—

This machine is a complete plant, and includes the bottling. Let this description suffice.

G is the body of generator with opening at top to admit the proper charge of whiting, or marble dust. H is handle to stir up the compound when the vitriol is running in. V is the Vitriol Pot having an opening in the top to admit the proper quantity of sulphuric acid; R being the crank of the lever which allows the acid to run slowly into the generator G. E is the Blow-off pipe by which the exhausted material is discharged from the generator after a charge is made. WW are the washers for purifying the gas on its passage to the Cylinders. CC are the



Cylinders for holding the water to be aerated. P is the Pump for forcing in a fresh supply of water when all has been bottled off. BB are the taps for allowing the gas to pass into the water to be aerated. AA are taps for passing the water to the Bottling Machines, one being in use whilst the other Cylinder is being charged, the bottling thus being continuous. HH are the agitators for agitating the water thoroughly whilst the gas is passing in, and so making the water take up the gas rapidly. S is Safety valve.

In making a charge proceed as follows:—

First fill the cylinders CC quite full of water through the opening at top of each.

Put the water into the generator through the hole on top, then add the necessary quantity of whiting, put on the cap and screw it down, agitating the compound steadily to make it thoroughly dissolve; do this steadily to prevent the mixture being thrown into the pipes. If preferred the necessary quantities of water and whiting may be first mixed in a tub and then put into the

generator. Close the valve of lever R and put the necessary quantity of vitriol (sulphuric acid) in acid pot V.

Fill the washers about two-thirds full of water and screw down all the caps tightly. Close the tap on washer at the joint where the gas goes down into cylinder CC.

All being now ready, by means of handle R allow the vitriol to run gradually into the generator, agitating slowly by means of handle H until the guage shows a pressure of about 150 lbs., Stop the supply of vitriol, discontinue agitating, and slowly open the tap on washer nearest the cylinder C, allowing the gas to pass into it. Shut the tap again almost immediately and draw off about one-and-a-half gallons of water from each cylinder CC, by this means you get the necessary empty space in cylinders for gas, and at the same time get rid of all atmospheric air; after first time of charging, the cylinders are filled by means of the pump P, thus avoiding all atmospheric air so necessary to the making of good Aërated Water. Having drawn off the necessary amount of water, open the tap again and allow the gas to pass into the first cylinder, turning the handle H sharply until the guage shows that more gas will not pass, then close the tap and proceed as before by letting in more vitriol until the guage again indicates 150 to 160 lbs. pressure, then again close valve and discontinue agitating generator, and allow the gas to pass into the same cylinder again. Repeat this until guage shows that you have 150 or so in the cylinder, always agitating the water thoroughly by handle H. To break the water and make it take up gas more rapidly, reverse the action by turning handle H from right to left for an instant. When one cylinder is so charged close the tap B and open A; the water being now ready for the bottler, who can go on with his work whilst the other cylinder is being charged.

Having passed all the gas that the charge will make, a pressure of 40 or 50 will be left in the generator, use this to blow off the exhausted material by means of pipe E; this material should never be left in generator all night or it becomes caked and hard. Though when bottling off the water the pressure in the cylinder will run down considerably, still there is always left a greater pressure than is necessary to go into the bottle, and the experience of the makers and customers proves that the last bottle will be as good as the first, that is, as fully impregnated with carbonic acid gas.

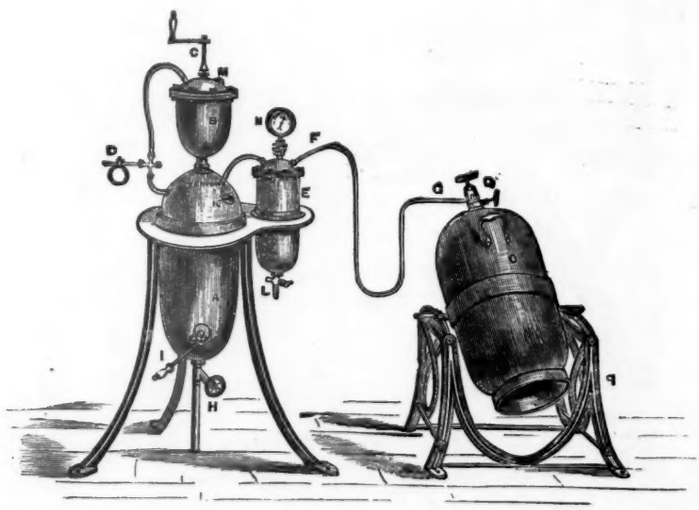
Should a cylinder once charged be left for a night or several days only part full, before commencing to bottle from it, agitate handles HH sharply for a few seconds, this will cause the water to again take up the gas which rises from the water into the empty space above it, making it as good and sparkling as when first made.

The generator should be rinsed out with water after each charge, and it is best to leave it part full of water when not in use.

The water in washers must be renewed each charge.

Quantities of material to be used are supplied by the makers of the horizontal generator, some allowance, however, must be made for the quality of the vitriol and whiting or marble dust.

The next illustration is that of the Upright, which can be used either with stationary or portable cylinders, the principle



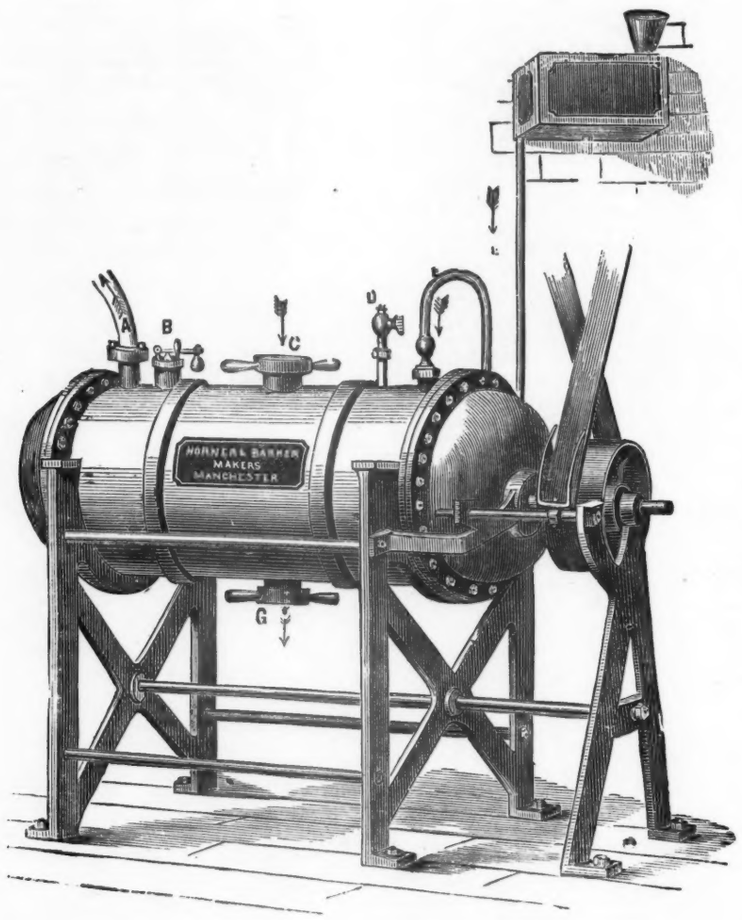
being the same. A is the body of the generator; K, the opening for marble dust or whiting and water; E, the washer or purifier; B contains the sulphuric acid; C, the handle regulating the supply of its contents to the generator below. N is the pressure guage; D, the safety valve; G, the elastic pipe connecting the generator with the cylinder to be changed. Q and F are the taps in connection. O is the cylinder on the rack P; M, the opening into the sulphuric acid vessel. I is the regulating handle for agitating the materials; H, lets off the waste material by means of pipe, &c. In its general working it differs little from the horizontal generators, but it is a very useful specimen, especially when you require the production of compounds; then it is imperative. Imperative it will be: there cannot be a question about the ultimate popularity of the saccharine drinks, the aerated ginger beer, and the fermented, and the champagne cider, ginger ale, and champagne cup, to say nothing of the long catalogue of essences and extracts, coloured with every hue, and pungent with all that capsicum and cayenne can accomplish, and perhaps there may be an infusion of alcohol. The public taste pursues its own course; with that we ought not and cannot interfere, because it is precisely our duty to describe how these things are done. This machine ranks among the most ingenious of any that has come before the public notice, and its utility will bring it into service in mansions, and in secluded places of resort that are frequented by persons of refinement, who do not desire gross indulgence.

The next figure is that having an horizontal generator, and is thus correctly described:—D is the generator, in which is put the carbonate used, either whiting, bi-carbonate of soda, or carbonate of lime, called "marble dust." This and the water are introduced through a funnel at the top. The sulphuric is then poured into A, and care taken to close the shut-off G. The vitriol pot and generator, lined with thick lead, are then closed tightly by screwing down the brass nuts. C is the cylinder, which is tinned inside, and contains the soda water. In this is poured the water required, through the top opening, and the nut screwed down. B is the washer, and is three parts filled with water to purify the carbonic acid gas which then passes through pipe L into cylinder.

There is another form that claims to be an improvement. It is of a larger size, and works with the double machinery. Fast and loose pulleys are fitted on a short iron shaft with strap, fork, &c.; the iron shaft being connected by set screws, with a spindle that runs through the generator. The agitator is made of gun metal, and heavily tinned, and is placed near the bottom, so that the fans are continually immersed in the whiting. It is placed in a position that prevents its blocking up the outlet to the gasometer. All the connections are lead flanges, held together by gun-metal plates, thereby avoiding continuous wear, and the effect of acids on the threads. The body is of the best chemical lead, and jointed so as to render it completely impervious to the action of acid. These generators have a

valve attached to take off sudden pressure, and a gun-metal cock for supplying water direct from the main.

Our sketch is thus described :—A, the pipe conveying the gas to the gasometer ; B, the safety-valve ; C, the inlet for whiting ; D, the stop-tap for water-main connection ; E, the syphon pipe connected with the acid-box ; F, this arrangement obviates the objections to the use of the acid bottle ; G, is the outlet for the whiting.



There is a contrivance for charging and conveying these aerated waters, made of strong copper, heavily lined inside with the purest tin ; and the following are the two views, sectional and external. This can be used with the bottling apparatus on reaching its destination, or set under the counter and be connected with an apparatus for supplying the public *ad libitum*.

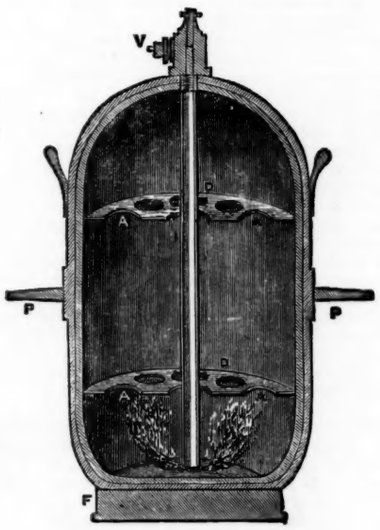
Its great advantage is due to the automatic valve by which, as the bottle fills, the atmospheric air in the bottle is blown off, doing away with the necessity of releasing the bottle, and so losing the gas ; by this valve also, every bottle, when filled, contains the same pressure, which can be fixed at any given pressure as desired ; this regularity of pressure adds very much to the quality of the water, and gives more satisfaction to the consumer than waters filled at uneven pressures.

To charge with soda water the cylinder is filled nearly full of water, and then being placed on the agitator rack, is attached to the generator by the flexible rubber pipe, and, as the gas passes in, the cylinder is oscillated, the water striking against the two discs DD is broken, and the gas is then quickly taken up by the water. The pipe in centre acts as a syphon, and is used to draw off the contents when fully charged. All these cylinders are tested up to 300 lbs. pressure before being sent out.

The manufacture of soda water, &c., is not reduced to a positive invariableness. We have stated that notwithstanding the scientific superiority of the American methods, and the guarantee arising from the fact of aerated waters being almost a universal beverage in that continent, our English makers—even the largest—still adhere to the old ways. But the danger arising from the use of the old machines is much greater than the public is aware of. The carbonic acid gas is generated in a *lead* vessel *supposed* to be sufficiently strong, but it has no pressure gauge or safety valve. This lead vessel is connected with a pipe to the reservoir or gasometer ; now, supposing this pipe becomes choked or stopped up (which is possible), the result would be an explosion of the generator, and the lives of those who work the machines are sacrificed, or placed in great peril. This, however, would not be the fault of the workman, but rather of the maker, whose business it is to provide against such accidents. The English machines are complicated, and liable to get out of order. The pumps and different valves, the lead generator, the gasometer, the multiplicity of pipes and connections, are such that only a thorough mechanic can safely be entrusted with them ; while, on the other hand, the simplicity, durability, and effectiveness of the improved machines are at once apparent by a moment's comparison. Again, a machine advertised to make 200 dozen bottles per day, when tested fails to accomplish more than 50 dozen, and the purchaser is disappointed and *grossly* deceived.

Aerated waters are dispensed to the public in bottles, except where they are sold from the counter, which method, howsoever acceptable in America, has not as yet acquired general acceptance here. Mechanical science has had much to do in producing instruments that perform this service, and the story is a wonder-

ful one. The real pivot of the whole trade turns on the facility and perfection of bottling. What is the use of a vat of aerated waters unless they can be promptly divided into quantities, and duly enclosed. In England there is a growing desire for the



supply of combined aerated waters and syrups, and it has been a very difficult operation to construct machinery for that purpose. The best we know of as what is called a "Filling Machine," is the Automatic herein represented.

THE MANUFACTURE OF STEARIC CANDLES AND GLYCERIN.

IT is only about fifty years since Chevreul, Gay, Lussan, and Cambacérès, took out their patents for the manufacture of stearic candles from common tallow. The scientific researches of the first named chemist, upon which these patents were founded, great and admirable as they were, were speedily added to by others, and in 1831 A. de Milly introduced the use of lime for saponifying the tallow, his predecessors having used potash and soda. Candles made by De Milly's patent must be familiar to all visitors to France under the name of *Bongias de l'Eloile*. They far exceeded in whiteness, hardness, and lighting and burning qualities, the productions of his rivals, and for ordinary purposes, at least, quickly drove wax and sperm candles out of the market. At the present day the stearic candles not only holds much more than its own in its classical wax-light, but the common sorts have become so excellent and cheap that they are replacing the middle class moulds, and the poor man's dip and rushlight. An excellent hard, clean, white composite candle requiring no snuffing may now be bought for a halfpenny, which gives twice the light of the old-fashioned dirty evil-smelling smoky dip.

One of the reasons for these great improvements is that, for many years past, the three products of the saponification process, viz., stearic acid, oleic acid, and glycerin, have all been turned to profitable account, whereas at first the last two products were drugs in the market.

The lime saponification process, in which, from 14 to 17 per cent. of lime was used, was almost exclusively employed up to 1845, and even in 1867 it was not entirely abandoned. Saponification under pressure, at 160 deg. F., by which the amount of lime was diminished to from 2 to 4 per cent., was invented by Milly and Molard in 1854, and improved upon by Milly in 1855. This process, or a modification of it, is generally used throughout Germany, Austria, France, and Italy. Wherever there is a large and cheap supply of tallow this process in connection with soap-making is carried on in preference to any other. The weak points of the process are the incomplete saponification of the tallow, and the consequent presence of a quantity of neutral olein in the oleic acid, which dissolves a certain quantity of the stearic acid. This dissolved stearic acid becomes lost in the pressing process. For these reasons the lime saponification process gives a smaller yield of candle making material, than the saponification by sulphuric acid combined with distillation.

The idea of decomposing neutral fat by the action of superheated steam alone without the use of either acids or alkalin is due to Telghmann and Melsens, who worked independently of each other. The process, when carried on by means of Wright and Fouche's apparatus, drawings of which are in the French Reports of the Exhibition of 1867, yields good results. This process, effective as it was, seems to have died out. The last we hear of it is on the authority of Stas, who tells us that in 1863 it was in full operation at Vienna. Two years later the Viennese manufacturers, one and all, adopted De Milly's method of lime saponification under pressure. The great defect of Telghmann's and Melsens's process was incomplete saponification, even under a pressure of 14 atmospheres.

If after acting on grease by superheated water we distil the products obtained by means of superheated steam the saponification is complete, but the results are not so good, the oleic acid, for instance, being of a bad colour—as when the lime process is adopted. Wilson and Payne used this process for the saponification of palm oil for a short time at Price's Patent Candle Company's works at Battersea and Belmont. It was abandoned for another process, in which the saponification is commenced by sulphuric acid and completed by distillation. The sulphuric acid method of saponification is the foundation of all the latest improvements in stearic candle making, which have been invented during the last ten years. France and England both dispute the honour of having discovered this process, but according to Dr. Karl Krant, professor of chemistry at Hanover, from whose report we take much of the information contained in this article, the patents of Wilson, Jones, and Gwynne, show that these researches were prior to those of Frénny, Melsens, and Dubrunfaut. At first large quantities of acid were used in both countries, but this resulted in the decomposition of part of the fatty acids and glycerin. In 1861 the amount of sulphuric acid employed for saponifying the palm oil used at Price's works was (the process being carried on at a temperature of from 330° to 350° F.,) reduced to 5 per cent. A black solid mass was thus obtained, which was washed and then distilled in a current of superheated steam at a temperature of from 550° to 570° F. The first distillate could be used at once for candles, those which came over afterwards had to be redistilled after having been submitted to the action of the press. At one time Price's company used a modification of Telghmann's and Melsens's processes, in which superheated steam alone is used, but the former process was ultimately resumed. De Milly about this time invented a process which did away with the discolouration of the fatty acids, and the decomposition of the oleic acid The fatty matters are heated to 250° F., and mixed with 6 per cent. of sulphuric acid at 66° beaumé, and at the end of a couple of minutes with boiling water. The washed fatty acids are

compressed twice, and yield white cakes of stearic acid, ready for immediate use, and slightly coloured oleic, and which must be redistilled. The superiority of this process over the two lime processes is, that while the yield of fatty acids is much greater, their excellence, as candle making materials, is in no way diminished. De Milly's new process was a sore puzzle to scientific chemists of the day. Theoretically speaking, 11 per cent. of pure sulphuric acid would be required to saponify a certain amount of tallow, but careful investigation proved that in practice it was only necessary to use about half that quantity. The only way of solving the difficulty was by supposing that the water which was mixed with the sulphuric played an important part in the saponification of the tallow. This turned out to be correct, and Messrs. Roubaix-Jenan and Jamesens, of Cureghein, near Brussels, patented a process by which the amount of sulphuric acid was further reduced to 3¼ per cent. Equal parts of tallow and palm oil were taken and mixed with the necessary amount of sulphuric acid and water at 212° F. The mixture was then heated up to about 250° F., and well agitated for ten minutes. It was then allowed to rest, after which it was decanted. The black residue was then boiled for two hours with ¼ of its bulk of water. The fatty acids were then distilled off and purified in the usual manner. By this method the formation of a certain amount of pitching matter could not be avoided; but Stas, acting on a large scale, found that the unavoidable waste of material did not amount to a twelfth of the whole.

About this time great efforts were made to transform oleic acid, which is only useful for soap-making, into one or other of the hard fatty acids, but without success from a practical point of view. Vanmtrap, it is true, succeeded in converting oleic acid into palmitic acid and ascetic acid by the use of caustic soda in a state of fusion, but the process was too expensive to be carried out on a commercial scale. Pelvinge and Frency transformed the oleic acid into elardic acid with nitric acid. Wilson, Jones, and Gruynne also patented a process for converting oleic acid into palmitic acid, but all these processes, ingenious as they were, were open to the same objection—they were not practical on a large scale.

In 1859 Mège Momiès devised an ingenious process of saponification by alkalics. He first mixed the grease with a certain amount of hot soap solution, and added the necessary amount of alkali, for the complete saponification of the whole. The mixture, on being heated to 140° F., separated into two layers, the lower being the almost pure soap. The supernatant lye being dicanted of the soap, was decomposed with sulphuric acid. By this process the fatty acids were obtained from any admixture of oleic acid. Although the yield was greater than by any other process, this method of saponification had to be abandoned on account of its dearness.

A slight sketch of the process now adopted by Price's Patent Candle Company will be of interest to our readers.

In 1854 Tilyrunann, taking advantage of Milly's discovery that water played a large part in the reactions that took place during the saponification of the grease by sulphuric acid, patented a process for saponification fats and oils by the use of water alone, at a high temperature and under great pressure. He professed to effect this by driving a mixture of fat and water through a coil of pipe heated to 612° F., at a pressure of about 133 atmospheres. The vessel in which this operation is performed, must be closed, and able to bear the pressure, so that the water shall not be connected with steam. Mr Wilson, the manager of Price's Company, further improved upon this process by passing steam into fat, at a high temperature, by which method many thousands of tons of soft evil-smelling palm oil are annually converted into hand-white candles. The process as it now stands, is nearly as follows, but it must be borne in mind that modifications and improvements are being constantly made.

When concentrated sulphuric acid is made to act on fat or oils at a high temperature, compounds known as sulpholeic, sulphostearic, and sulphopalmilic acids, are found, together with a quantity of mephoglycerin acid. The first three sulphoacids are soluble in plain water, but are insoluble in undulated water. On raising the temperature of these solutions, they become decomposed, the sulphuric acid is not at liberty, and the fatty acids and glycerin are separated. If the sulphuric acid and fatty matter be made to act upon each other at a high temperature, another kind of reaction takes place. The sulphoacids are decomposed as fast as they are found, the result being the entire separation of the fatty acids, while the sulpho-glycerin is partly decomposed into carbonic and sulphurous acids. It is upon these two reactions that the processes now practised by Price's Company are founded. The fatty materials in matter of that description is first melted and freed from impurities by straining and skimming. It is then mixed with from one-twelfth to one-seventeenth its weight of oil of vitriol of the specific gravity of 1·842 in large copper boilers, and is raised by a current of superheated steam to a temperature of about 350° F. This temperature is steadily kept up for about two hours, the mass being frequently agitated by means of revolving dashers. Carbonic acid and sulphuric acid now begin to be disengaged in large quantities, nearly the whole of the glycerin and sulphuric acid being decomposed during the operation. The laterated fatty acids are of a dark colour, and are next thoroughly washed with water, to free them from adhering sulphuric acid. The impure fatty acids thus obtained are then subjected to distillation, which is effected by placing them in a copper vessel, with the lower part of which a current of steam at the ordinary pressure, is injected; the steam itself, however, being brought to a temperature of about 600° F. by passing it through red-hot pipes. The distillation takes place at about 400° F., but towards the latter part of the process the temperature rises to about 500° F. Most of the fatty acids being distilled off a considerable amount of blackened residue remains in the retort. This by pressure may be made to yield a large quantity of fatty acids—the black pitchy matter remaining behind being used as fuel. Let us return, however, to the distilled fatty acids. The cakes are broken up into small lumps and distributed in layers of about ¼ of an inch in thickness upon squares of cocoa-nut matting, which are made into a pith, and squeezed in a hydraulic press. The mixture of stearic and pulmitic acids then obtained is sufficiently firm to be made at once into candles for the European market, but for India they must be submitted to a still further squeezing at a temperature of 120° F. Mr. Wilson further improved upon Telghmann's process for using water alone as the saponifying agent, by injecting superheated steam of a temperature of between 500° and 600° F. into heated fat, by which he effected, not only the simultaneous distillation of the fatty acids so formed, but of the glycerin also. Glycerin obtained by this process is a beautiful colourless syrupy liquid, which can be prepared in almost unlimited quantities. The fatty acids are also obtained in a high state of whiteness and purity, and the operation, although a slow one as compared with the sulphuric acid process, promises to supersede those previously employed. Certain difficulties in the way of applying this process to all fats have yet to be overcome.

The details of this process are as follows:—The neutral fat after having been purified in the ordinary manner is placed in large retorts, which are raised by direct pressure heat to a temperature of about 570 deg. F., and superheated steam about 600 deg. F., is injected continuously amidst the molten fat for from twenty-five to twenty-six hours. By this means the glycerin and fatty acids are as perfectly separated as in the saponifying in sulphuric acid process, and as the operation proceeds, distil over into suitable receivers in an atmosphere of steam. The process is a somewhat delicate one; a successful result depending on the careful regulation of the heat. If the temperature is too high the fatty acids and glycerin begin to decompose on their own account into acrolein gaseous hydrocarbon and tarry residue, which if not sufficient, the glycerin is only imperfectly separated from the fatty acids. This, however, is not the great objection to the process, for by exercising proper care the heat can be regulated to a nicety. The chief reasons why this beautifully simple process cannot be universally applied in England at least are, that our principle raw material for candle making is palm oil, the colour of which is yellowish brown. Now the process last described leaves this colour untouched, whereas in the sulphuric acid process this very objectionable tint was destroyed. It may be remembered that some years ago a yellowish candle was brought out, selling at a very low price, and called the "Victoria dip." It was, in fact, a brown stearic candle, equal in every respect to white stearic candles selling at half again as much. It was hard, snuffless, and did not drop grease about and light; and it was cheaper than the common dip, but it had one great fault, which overruled all its virtues—it was brown, and the public would have none of it, preferring the dearer and dirtier halfpenny dip, which, if not absolutely white, was a near approach to it. So much for ignorant prejudice.

The sulphuric acid process affords the further advantage of refining, otherwise improving fats. Formerly the best tallow only, Petersburg Yellow Candle, or P. Y. C., as it is called in the trade, was used for making the best quality of candles, but of late years good tallow has been used in such great and increasing demand for lubricating heavy machinery in iron works, and for other purposes, such as fresh butter making, that the candle maker is thrown back on palm and cocoa-nut oil, kitchen stuff and other refuse fatty matter. In the majority of cases, therefore, stearic candles are now made by the sulphuric process. The latest researches having for their object the conversion of the liquid olein contained in palm oil and other fats in solid elain, so as to allow of its being converted into solid elaidic, and fit for being

used in company of its conjurers for making solid candles, are those of Mr. Cambacérès, who states, that by acting with very dilute nitric acid on melted fat at a temperature of 206 deg. F., for four hours its swelling point was raised 18 deg. to 20 deg., showing that a certain amount of the liquid olein had become converted into solid elaidic or some other solid fat. After proper washing and drying the hardened material is saponified by the sulphuric acid process, and the hard fatty acids extracted by distillation or compression or both. The yield of solid fatty acids, melting about 122 deg. F. by this process, is stated by the inventor to be increased by 12 per cent. A great field is open to both, the chemist and manufacturer; in this direction a practicable and cheap process for converting oils into solid fats would be a boon to the candlemaker, who, in spite of the improvements which have taken place in this branch of industry during the last few years, still finds it a hard matter to fight against the cheaper and nartic kinds of mineral oils.

As far as the mechanical part of the manufacture goes we have but little to chronicle. The light petroleum oils and bisulphide of carbon have been proposed as agents for the separation of the solid from the liquid fatty matters, but without success. Since artificial butter making has become such a large industry a great demand has arisen for purified soft fats. By pressure and other means these are now separated from tallow, and purified from every trace of rancidity. The remaining hard tallow is eagerly bought up by the candlemaker, who is of course glad to get his raw material as free from olein as possible. The process is sometimes reversed, and the candlemaker supplies the butterine manufactures with soft fat. Their new appliances for rendering and purifying fats received a great impulse at the time of the siege of Paris, when that unfortunate city, having eaten up all her real butter, was obliged to put up with the artificial article, which had then only just been invented. One of the most ingenious and successful inventions for separating the softer parts of grease from the hard is a machine brought out about this time by Messrs. Weiss and Co. of Paris, which was constructed on the principle of the turbine.

We now come to glycerin, which, although formally looked on as a mere bye product of the manufacture of candles, has lately assumed a position of great importance. At one time it was the plague of the candlemaker, but now-a-days it forms one of his most profitable products.

Glycerin, as a separate body, was first discovered by Schule in 1795 while investigating the properties of lead plaster, the diachylon of the pharmacist, which is made by boiling lithange or oxide of lead in olive oil. He found that by adding water to the mixture and carefully heating he obtained a moist solution, which, by further evaporation, yielded a thick syrupy liquid of a sweet taste. This liquid on further heating partly distilled over without decomposition. It was not, however, until M. Chevreul published his researches into the composition of fats, etc., that chemists obtained a clear idea of the mixture of glycerin.

It is, as every one knows, a viscous colourless fluid of a sickly moist taste, slightly heavier than water, and mixing freely with that liquid and alcohol in all proportions. One of its peculiar characteristics is its excessive love for water. A drop of pure glycerin let fall on a marble slate will first grow larger by absorbing the moisture from the air. Having done this neither the glycerin nor the water which it has sucked out of the atmosphere will evaporate, and we may safely predict that the drop would remain unaltered in the same place practically for ever. Its repugnances to evaporate at ordinary temperatures renders it exceedingly valuable for a number of purposes where perpetual moisture is an advantage. It may be distilled, unaltered, in *vacuo*, or in a current of superheated steam, but under ordinary pressure it becomes decomposed by the oxygen of the air, producing pungent vapours of acrolein, similar to those produced by the smouldering wick of a common tallow candle. Most of its industrial uses, with the exception of the important manufacture of nitro-glycerin, are dependent on its non-volatility and power of absorbing moisture from the atmosphere. Thus the modeller uses it to maintain the moisture of the clay, and the drying up of mustard in hot weather is prevented by adding a few drops of glycerin to the water with which it is made. Ordinary ink becomes copying ink by the addition of a small quantity of glycerin, and it is added to the water of gas metres to prevent it from freezing in summer and evaporating in winter.

The dangerous explosive nitro-glycerin, which is now so universally used in the comparatively harmless form of dynamite, letho-fracture, and other similar compounds is made by treating glycerin with a mixture of concentrated sulphuric and nitric acids. Mankind, however, were a long time finding out these valuable properties, and it is only within the last twenty-five years that glycerin has come into common use.

The process which yields the largest proportion of glycerin in relation to the amount of fatty material is that in which superheated steam alone is used. The sulphuric acid process comes next, the per centage which escapes decomposition being from 6½ to 8 per cent. The lime saponification process, now almost abandoned in this country, only gives from 4½ to 5 per cent., besides which the resulting product is very impure and dirty, and difficult to obtain in a marketable form.

On looking back over the last ten years the striking improvements which have been made in the manufacture of stearic candles are comparatively few. This apparent dearth of invention must not be ascribed to any feeling of apathy on the part of the candle manufacturer, but rather to the fact that the art of separating the fatty acids from their fats had already reached a degree of perfection beyond which it is difficult to go. They would be only too glad to welcome any invention which would reduce the cost of manufacture, either by increasing the yield of fatty acids, or by lessening the expenses of plant or production. The candlemaker has had a hard battle to fight during the last ten years owing to the introduction of such a beautiful lighting material as paraffin on the one hand, and good and cheap mineral oils on the other. For an infinite number of uses candles, in one form or another, will never go out, no matter how cheap or excellent the minerals may become, and it behoves candle manufacturers to continue to strain every nerve to improve their already excellent products, and to cheapen them still further, although the poor needle woman can now buy a whiter, harder, brighter burning, snuffless candle, for a halfpenny, than could have been purchased ten years since for double the money.

Chemistry applied to the Arts, Manufactures, etc.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

Colouring of Iron and Steel.—Iron or steel articles placed in the following mixture, maintained at boiling temperature will take a fine blue tint :—Dissolve 4 oz. hyposulphite of soda in 1½ pints of water, and then add a solution of 1 oz. acetate of lead in 1 oz. of water.

Testing for Cinder in Iron.—To show the amount of finely-divided cinder in the composition of puddled iron, M. Chatelier heated a piece of this metal under the action of a stream of chlorine gas, so as to completely vaporise it. There remained a residuum of whitish-green colour and very light weight, having the general form of the piece of iron experimented upon. This was found to be composed wholly of finely-divided cinder.

Cask-making and Oil-refining in America.—The Standard Oil Company is constructing at Pittsburg a factory for the manufacture of barrels for its own use. The building will be 300ft. square, and supplied with the latest improved machinery for making barrels, with a capacity for turning out 5000 to 7000 barrels a day. The establishment, it is calculated, will cost about 50,000 dols. In connection with this immense cooperage there is being erected a huge agitator, to be used in completing the process of refining oil, and to which the oil will be conducted from the refineries in the neighbourhood by means of pipe lines, and barrelled. These establishments will have the effect of making the locality an extensive shipping point. The new pipe line between Great Belt and Pittsburg was finished on the 24th ult. It is thirty-six miles long, and will supply twenty-eight refineries in Pittsburg, all owned by the Standard Oil Company

Registration of Designs in Germany.—In September this year 8,517 designs and models were registered by 176 firms or individuals. Compared with August, this shows an increase of 5,828. Amongst the designs registered in August, were 4 of foreign origin—3 British and 1 French. There is an increase of 6,856 designs over September, 1876—making four times the number in that month. During 1877 there have been registered, up to the end of September, 37,525 designs. Since the commencement, the total number of registration is 50,224. Among these were only 7 foreign, namely, 3 British and 4 French. It appears, therefore, that little heed is paid out of Germany to this important branch of trade registration there,

one which cannot but have a very decided bearing upon industry. It is necessary to draw attention to the matter, since British manufacturers cannot be indifferent to seeing their designs and models protected abroad as well as at home.—*Trade Marks.*

Automatic Clock by Glycerin.—An automatic clock is described by Herr Helling, in which the winding machinery is operated by the alternate expansion and contraction of glycerin, or other suitable liquid. A piston, on the surface of the glycerin, is so connected with ratchet wheels and toothed racks, that motion in either direction will wind up the weight. The inventor thinks that the contrivance will be especially valuable for self-registering meteorological instruments.

Electrical Lighting.—In the city of Providence, R.I., 220 street lamps, within a district over nine miles in length, are now lighted and extinguished in less than fifteen seconds by electricity, and the system is controlled by one man. After a trial of several months, the practicability of the plan is assured, and if the whole of the 2500 lamps in the city were lighted in this way, it is estimated that a net saving in expenditure for gas and labour would amount to about 25,000 dols. per annum.

Spanish Tramways.—We are informed that Mr. W. Abbott, of Tokenhouse-yard, has been invited to visit Madrid for the purpose of discussing and considering various plans for the extension of tramways in that city. The opportunity has been taken for visiting several other Spanish cities, with the view of introducting steam power on such of the tramways as are now worked by horses, the results already obtained from the working of the Hughes' locomotive appearing to justify the more extended employment of this engine. The concessions which have been proposed are reported to be of a valuable character. —*Railway News.*

New Night Signal at Sea.—The United States Bureau of Navigation will soon put in use on board their navy the new "Very" Night Signal, invented by Lieutenant Very of the navy. By this plan of signalling, coloured fire stars are projected from 200 to 300 feet into the air by a pistol, so that a commander-in-chief may readily communicate with all his fleet in a crowded harbour, by a series of signals which may be seen and read by officers of all his vessels, notwithstanding the space between them may be crowded with other craft. By firing a signal red or green star, or a combination of them, all the sentences in the navy code may be communicated. The stars burn with brilliant red and green lights, and can be seen at a distance of from ten to twelve miles.

Types from Toughened Glass.—Some experiments have been made in France with a view to showing whether toughened glass can be pressed into the printer's service as a substitute for the metal of which types are made. The advantages in point of cleanliness would be not insignificant. But the *Patrie* points out that there are other and more solid improvements involved. The toughened glass, which is not to be made in quite the same way as that used for tumblers and wine glasses, and need not, of course, be quite so transparent, is naturally much harder than the old metal, and can hardly be crushed out of shape by those little accidents which spoil the type we employ. It is also capable of being cast into more delicate forms so that the difference between the thin and thick strokes can be more clearly defined. Finally, it is found that the new material can be cast in exactly the same moulds as the old, and therefore there need be no expense incurred in altering the machines and implements used in the manufacture of type.

Glass-Engraving by Electricity.—At the last meeting of the French Academy of Science a paper was read from M. Planté relative to a method which he has discovered of engraving on glass by means of electricity. Some short time back he was engaged in some experiments, in the course of which he had to pass a very powerful current through a platinum electrode contained in a glass tube, and was surprised to see that the latter was deeply corroded by the discharge. He immediately set to work to discover the cause, and the process referred to above is the result of his investigations. It consists in covering the plate to be marked with a concentrated solution of nitrate of potass, placed in communication with one of the poles of a battery, and in tracing out the design with the other pole, terminated by a platinum wire. If the object to be engraved is rounded, as, for instance, a tumbler or a decanter, the only difference is that some gummy substance must be added to the solution to keep it in its place. The platinum wire, surrounded by an isolating substance except at the end, is held in the hand, and any writing or drawing may be engraved on the glass at pleasure. A luminous furrow is produced everywhere that the electrode passes, and, whatever may be the rapidity with which it is moved, it leaves a clear impression traced on the glass. If the motion is slow the marks are deeper, and the same effect is produced by strengthening the current. If the platinum wire ends in a point the lines may be traced of extreme delicacy.

Bessemer Steel.—Less attention than they deserve has been given to the purely statistical aspects of the Bessemer steel trade. The substitution of Bessemer steel for malleable iron has been accomplished so largely and so rapidly, consequent upon the cheapening of the former product, that people seem to have had regard less to the growth of the steel manufacture than to the decadence of its sister industry, which that growth involved. Nor is this at all surprising, considering that statistics of the Bessemer process have not heretofore been very readily accessible. In our own country, for example, there are no official statistics of the steel trade published from year to year to which the public have access. It was not even until a few years ago that the "Mineral Statistics of the United Kingdom," issued from the Mining Record Office, took cognizance of the number of Bessemer steel works established in the country, nor was it until this year that it issued any statistics as to the number of works carrying on the Siemens and Siemens-Martin processes, which are now being adopted very largely both in this country and abroad. It yet remains for some official source to collect and circulate the statistics relating to the production and distribution of steel in Great Britain, and we are glad to learn that the British Iron Trade Association has taken this duty in hand. The figures which we shall here make use of will be largely borrowed from the forthcoming annual report of that Association on the iron and steel trades during 1877.

The Bessemer process can hardly as yet be said to have passed into the region of history. The incidents of its development are almost of yesterday, less than twenty years having passed since it was practically adopted. Previous to Mr. Bessemer's great invention, steel was chiefly manufactured by the process of Huntsman, who was the first to produce cast steel by fusion in crucibles placed among the coke of an air furnace. The steel produced by Huntsman's process—which is still carried on to a considerable extent in Sheffield in the manufacture of mild steel —cost from £40 to £60 per ton, according to the purpose for which it was required. Bessemer, however, produced steel equally suitable for certain ends by his so-called pneumatic process at £12 per ton, and, when his royalty had ceased, for considerably less even than this. Successive improvements introduced since the process was first given to the world have resulted in making Bessemer steel almost absolutely universal.